ALGAE, EUTROPHIC CONDITIONS, AND NUTRIENTS TOTAL MAXIMUM DAILY LOADS FOR VENTURA RIVER AND ITS TRIBUTARIES

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LOS ANGELES REGION
320 WEST 4TH STREET
LOS ANGELES, CALIFORNIA 90013

DRAFT: JULY 20, 2012

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

ASSETS	Assessment of Estuarine Trophic Status
BMP	Best Management Practice
BURC	Beneficial Use Risk Category
Caltrans	California Department of Transportation
CASQA	California Stormwater Quality Association
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CFS	Cubic Feet per Second
CWA	Clean Water Act
CZARA	Coastal Zone Act Reauthorization Amendments
DEM	Digital Elevation Model
DO	Dissolved Oxygen
DWR	Department of Water Resources
GIS	Geographic Information System
EPA	Environmental Protection Agency
FOTG	Field Office Technical Guide
LA	Load Allocation
LARWQCB	Los Angeles Regional Water Quality Control Board
LiDAR	Light Detection and Ranging
MANAGE	Measured Annual Nutrient loads from Agricultural Environments
MGD	Million Gallons per Day
mL	Milliliters
MOU	Memorandum of Agreement
MS4	Municipal Separate Storm Sewer System
NAIP	National Agriculture Imagery Program
NEAA	National Estuarine Eutrophication Assessment
NOAA	National Oceanic and Atmospheric Administration
NMFS	National Marine Fisheries Service
NNE	Nutrient Numeric Endpoint
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NRCS	Natural Resources Conservation Service
NTS	Natural Treatment System
OWTS	Onsite Wastewater Treatment Syatem
OVSD	Ojai Valley Sanitary District
QAPP	Quality Assurance Project Plan
REC-1	Water Contact Recreational Use
REC-2	Non-contact Recreational Use
SBCK	Santa Barbara Channelkeeper
SCAG	Southern California Association of Governments
SCCWRP	Southern California Coastal Water Research Project
SMC	Southern California Stormwater Monitoring Coalition
SWRCB	State Water Resources Control Board
TIN	Total Inorganic Nitrogen

TN	Total Nitrogen
TP	Total Phosphorus
TMDL	Total Maximum Daily Load
UCSB	University of California, Santa Barbara
US EPA	Unites States Environmental Protection Agency
USDA	United States Department of Agriculture
USGS	United States Geological Survey
VCAILG	Ventura County Agricultural Irrigated Lands Group
VCWPD	Ventura County Watershed Protection District
WDR	Waste Discharge Requirement
WLA	Waste Load Allocation
WQA	Water Quality Assessment
WQO	Water Quality Objective
WWTP	Wastewater Treatment Plant

1. INTRODUCTION

The Ventura River Estuary and the Ventura River (including its tributaries), located in Ventura County, are identified on the 1998, 2002, 2006, and 2010 Clean Water Act (CWA) Section 303(d) list of impaired waterbodies due to algae, eutrophic conditions, low dissolved oxygen, and nitrogen (Table 1-1). The CWA requires the development of Total Maximum Daily Loads (TMDLs) to restore impaired waterbodies to fully support their beneficial uses. This document provides the background information used by the California Regional Water Quality Control Board, Los Angeles Region (Los Angeles Regional Board) in the development of the TMDL for Algae, Eutrophic Conditions, and Nutrients in the Ventura River and its Tributaries.

Table 1-1 CWA Section 303(d) list of algae, eutrophic conditions, and nitrogen impairments in the Ventura River and its tributaries

Waterbody Name	Pollutant(s)
Ventura River Estuary	Algae, Eutrophic
Ventura River Reach 1 and 2 (Estuary to Weldon Canyon)	Algae
San Antonio Creek	Nitrogen
Cañada Larga	Low Dissolved Oxygen

As documented in this staff report, the algae and nutrient-related impairments are caused by excessive loading of nutrients, particularly nitrogen and phosphorus to Ventura River and its tributaries.

1.1 Regulatory Background

Section 303(d) of the Clean Water Act (CWA) requires that "Each State shall identify those waters within its boundaries for which the effluent limitations are not stringent enough to implement any water quality standard applicable to such waters." The CWA also requires states to establish a priority ranking for waters on the 303(d) list of impaired waters and establish TMDLs for such waters.

The elements of a TMDL are described in 40 CFR sections 130.2 and 130.7 and Section 303(d) of the CWA, as well as in the U.S. Environmental Protection Agency guidance (U.S. EPA, 2000a). A TMDL defined as the "sum of the individual waste load allocations for point sources and load allocations for nonpoint sources and natural background" (40 CFR section 130.2) such that the capacity of the waterbody to assimilate pollutant loadings (the Loading Capacity) is not exceeded. TMDLs are also required to account for seasonal variations, and include a margin of safety to address uncertainty in the analysis.

States must develop water quality management plans to implement the TMDL (40 CFR section 130.6). The U.S. EPA has oversight authority for the 303(d) program and is required to review and either approve or disapprove the TMDLs submitted by states. If the

U.S. EPA disapproves a TMDL submitted by a state, U.S. EPA is required to establish a TMDL for that waterbody.

A schedule for development of TMDLs in the Los Angeles Region was established in a consent decree (Heal the Bay Inc., et al. v. Browner C 98-4825 SBA) approved on March 22, 1999. The consent decree combined waterbody pollutant combinations in the Los Angeles Region into 92 TMDL analytical units. In accordance with the consent decree, this TMDL addresses the waterbodies in analytical unit 88. This document summarizes the analyses performed and presents the TMDL for Algae, Eutrophic Conditions, and Nutrients in the Ventura River and its Tributaries.

1.2 Elements of a TMDL

There are seven elements of a TMDL. Sections 2 through 7 of this document are organized such that each section describes one of the elements, with the analysis and findings of this TMDL for that element. The elements are:

- Section 2: Problem Identification. This section reviews the data used to add the waterbody to the 303(d) list, and summarizes existing conditions using that evidence along with any new information acquired since the listing. This element identifies those beneficial uses that are not supported by the waterbody; the water quality objectives (WQOs) designed to protect those beneficial uses; and summarizes the evidence supporting the decision to list each reach, such as the number and severity of exceedances observed.
- Section 3: Numeric Targets. The numeric targets for this TMDL are based upon the WQOs described in the Basin Plan.
- Section 4: Source Assessment. This section develops the quantitative estimate of nutrient loading from point sources and nonpoint sources to the Ventura River and its tributaries.
- Section 5: Linkage Analysis. This analysis shows how the sources of pollutants discharged to the waterbody are linked to the observed conditions in the impaired waterbody.
- Section 6: Pollutant Allocations. Each pollutant source is allocated a quantitative load that it can discharge to meet the numeric targets. Point sources are assigned waste load allocations (WLAs) and nonpoint sources are assigned load allocations (LAs). Allocations are designed such that the waterbody will not exceed numeric targets for any of the compounds or related effects. Allocations are based on critical conditions, so that the allocated pollutant loads may be expected to remove the impairments at all times.
- Section 7: Implementation and Monitoring. This section describes the plans, regulatory tools, or other mechanisms by which the WLAs and LAs may be achieved. The TMDL provides cost estimates to meet the WLAs and LAs. The TMDL includes a monitoring program to assess TMDL effectiveness and attainment of water quality standards. It also describes special studies to address

uncertainties in assumptions made in the development of this TMDL and the process by which new information may be used to refine the TMDL.

1.3 Environmental Setting

The Ventura River watershed (Figure 1-1) is located in the northwestern portion of Ventura County with a small portion in the southeastern portion of Santa Barbara County. The watershed drains a fan-shaped area of about 220 square miles with an elevation from 6,000 feet to sea level. The Ventura River has several major tributaries, including Matilija Creek, North Fork Matilija Creek, San Antonio Creek, Coyote Creek and Cañada Larga. Matilija creek (15 miles) drains the Santa Ynez Mountains as it flows to the Matilija Reservoir and the Matilija Dam. The creek continues below the dam for about one half mile before it joins North Fork Matilija Creek. North Fork Matilija Creek, which is about 12 miles long, generally follows Highway 33 in the Los Padres National Forest until it joins Matilija Creek.

The Ventura River starts at the confluence of Matilija Creek and North Fork Matilija Creek. The Ventura River then flows for about 16 miles in a southerly direction to the estuary and the Pacific Ocean. The Ventura River has intermittent direct discharge to the ocean; longshore transport of sand can cause a sand bar to form at the mouth of the estuary in the late summer and early fall.

The Ventura River Estuary extends from the ocean to approximately 150 meters upstream of the railroad bridge based on tidal influence. The Estuary includes an open water area that is separated from the ocean by a berm that forms during the dry season. The berm is breached during storm events and slowly rebuilds through the summer, sometimes not fully building until August or September. The Estuary is flushed by tides when the berm is open and is dominated by slightly brackish to freshwater when the berm is closed (Ventura River Watershed State of the Watershed Report).

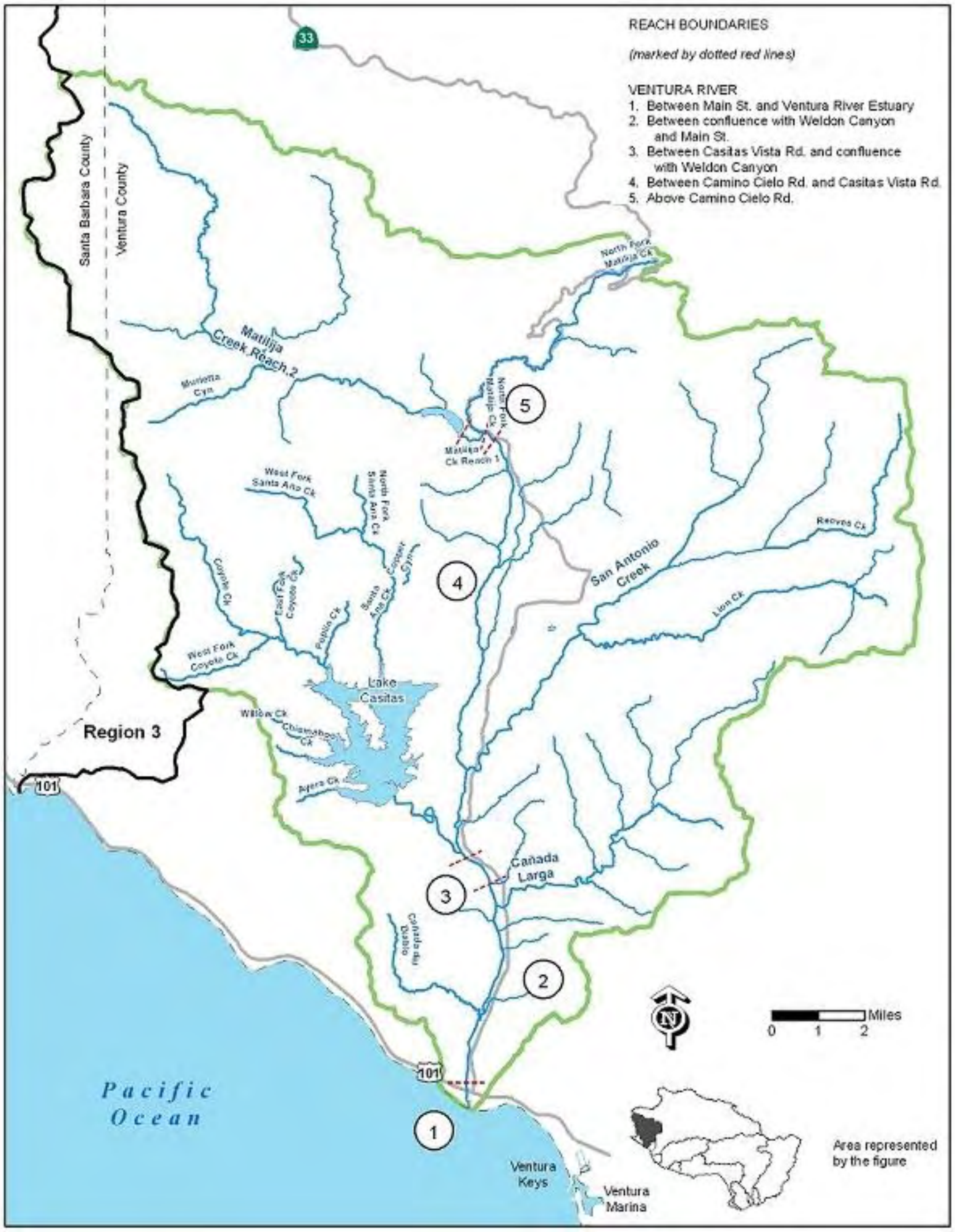

Figure 1-1 Major Surface Waters in Ventura River Watershed

The watershed topography is characterized by rugged mountains in the upper basins transitioning to less steep areas and valleys in the lower watershed. The gradient in the watershed ranges from about 150 feet per mile at the headwaters to about 40 feet per mile near mouth of the river. The U.S. Bureau of Reclamation classifies the watershed topography as fifteen percent valley, forty percent foothill, and forty-five percent mountain. The highest point in the watershed is at 6,025 feet in the Santa Ynez Mountains.

There are two reservoirs within the watershed: Lake Casitas and Matilija Reservoir. Lake Casitas serves as an important source of municipal supply water and is a popular recreation area. The Matilija Reservoir was originally constructed in 1947 to supply water for both agriculture and municipal uses and provide limited flood control. However, over the years large amounts of sediment has been trapped behind the dam and the storage capacity has been significantly reduced. Today the current dam capacity is estimated at less than 500 acre-feet (Tetra Tech, 2012). In 1998 studies were initiated to investigate the effect of removing the dam and the *Matilija Dam Ecosystem Restoration Project* was developed. This project aims to remove both Matilija Dam and the sediment accumulated behind the dam. Removal of the dam would eliminate a barrier to fish passage on Matilija Creek and facilitate the migration, spawning, and rearing of southern steelhead trout.

1.3.1 Land Use

Based on the Southern California Association of Governments (SCAG) Geographic Information System (GIS) database, eighty-five percent of the land use in the Ventura River watershed (Figure 1-2) is classified as open space and approximately one half of the watershed lies within the Los Padres National Forest. The Matilija Wilderness area, which is managed by the Los Padres National Forest and Ojai Ranger District, is an open space area with access only allowed by foot on marked trails. The remainder of the forest area in the watershed is designated as semi-primitive and has roads leading to recreation areas.
Agricultural land use is the second largest in the watershed at 4.5 percent of the watershed area. The developed area of the watershed is very limited compared to the open space areas, high density and low density residential land uses account for 1.9 and 2.9 percent, respectively. The cities of Ojai and Ventura are the largest urban areas in the watershed and the communities of Casitas Springs, Foster Park, Oak View, Valley Vista, Mira Monte, Meiners Oaks, Upper Ojai and Live Oak Acres are within the unincorporated Ventura County. Industrial areas in the watershed are generally used for oil production and mining and account for 2.1 percent of the watershed area. The remaining land uses (Public Facilities, Recreation, Commercial, Education Institutions, Horse Ranch/Livestock, Transportation, and Mixed Urban) each account for less than 1 percent of the land use within the watershed (Table 1-2).

Table 1-2 Land Uses of Ventura River Watershed

Land Use	Area (Square miles)	Percentage (%)
Open Space	186	84.6
Agriculture	9.98	4.5
Low Density Residential	6.33	2.9
Industrial	4.65	2.1
Water	4.17	1.9
High Density Residential	4.08	1.9
Public Facilities	1.17	0.5
Recreation	1.15	0.5
Commercial	0.70	0.3
Education Institutions	0.59	0.3
Horse Ranch/Livestock	0.57	0.3
Transportation	0.39	0.2
Mixed Urban	0.02	<0.1
Total of all classes	**220**	**100**

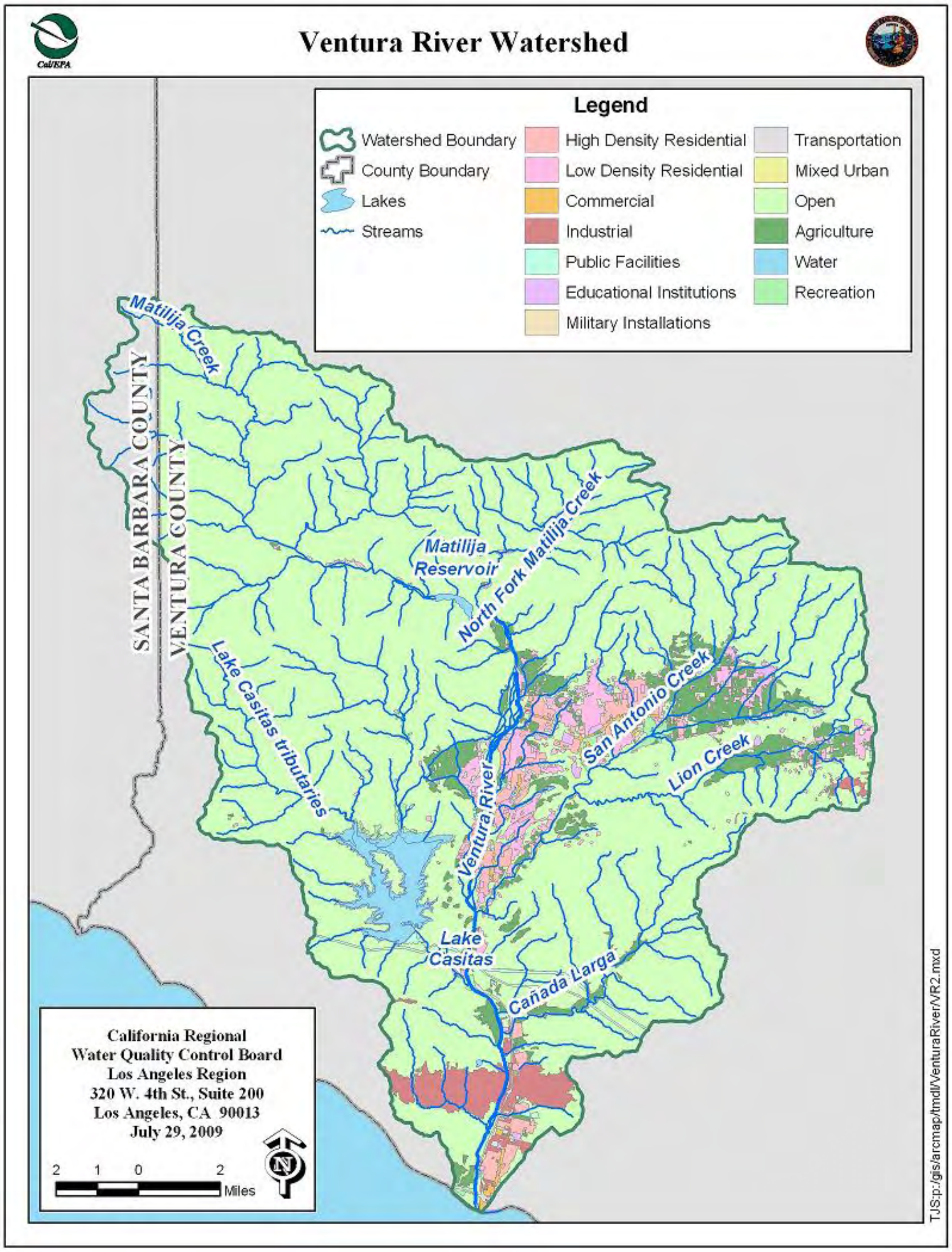

Figure 1-2 Land Uses of the Ventura River Watershed

1.3.2 Hydrology

Flow in the Ventura River varies seasonally due to the Mediterranean climate pattern of wet cool winters from November through March and dry warm summers from April through October. Annual rainfall can vary considerably from year to year. Figure 1-3 presents the annual rainfall from 2005 to 2010 as measured by Ventura County Watershed Protection District at Ojai County Fire Station.

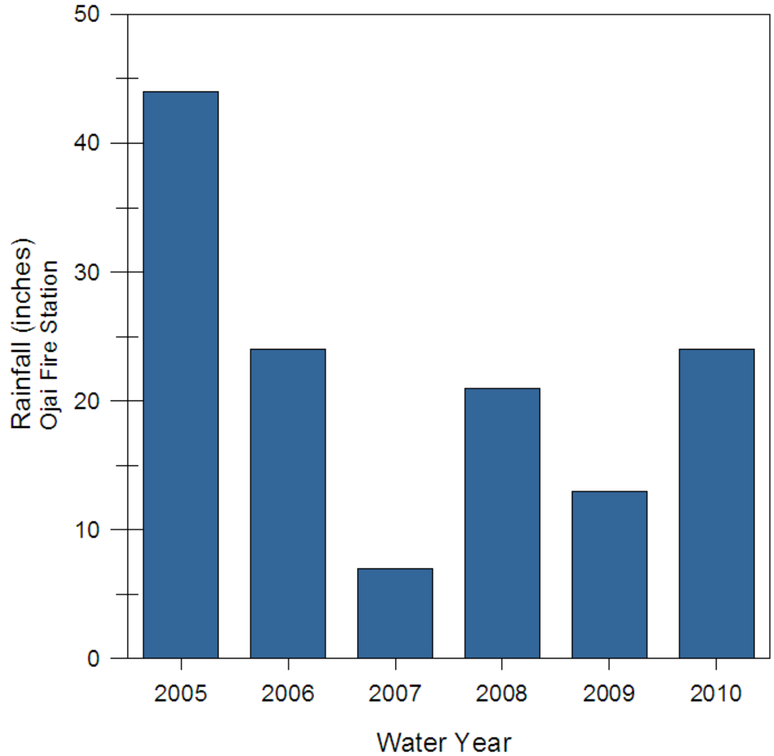

Figure 1-3 Annual rainfall at Ojai County Fire Station

High flows predominate during the rainy season, starting in winter through early spring. For example, Figure 1-4 presents flow in the Ventura River at Foster Park from October 2000 – 2008; peak flows occur after winter storm events and the flows decline to very low levels, less than 1 cfs, during the dry season. However, this pattern is mitigated in the lower Ventura River by effluent from the Ojai Valley Waste Water Treatment Plant (WWTP), which constitutes a majority or, at times, all of the flow in this section of the river during the summers and fall of dry years. The red hydrograph is the flow from Ojai Valley WWTP.

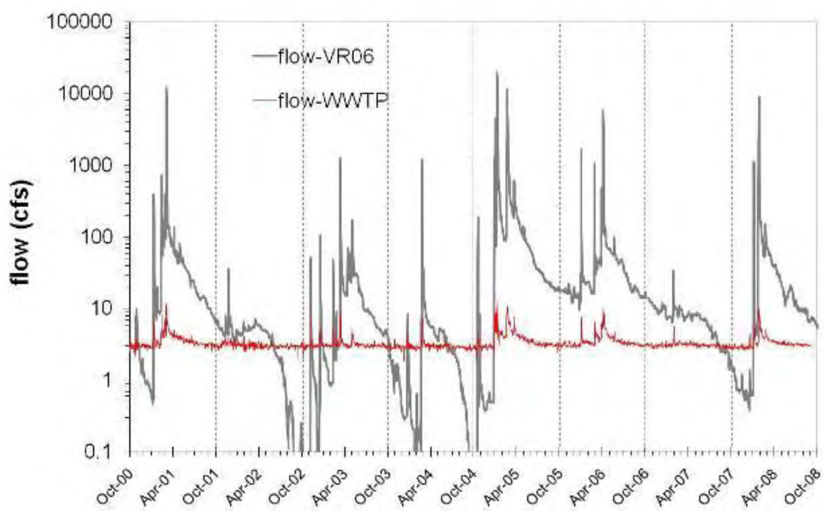

Figure 1-4 Stream Flow in Ventura River at Foster Park and Effluent Discharge from Ojai Valley WWTP (Klose et al., 2009)

In addition to natural variations in flow, based on annual rainfall, flow regimes in the Ventura River have been altered to support water supply. Typically there is perennial flow from the headwaters to the Robles Diversion Dam, which is located about two miles downstream from the Matilija Dam. The Robles Diversion Dam was built in 1958 and is used to divert water from the Ventura River into Lake Casitas via the Robles-Casitas Canal. The flow downstream of the Robles Diversion Dam to the confluence with San Antonio Creek is intermittent, particularly during the dry summer months. Geologic features in the area of Casitas Springs (lower part of Reach 4) causes rising groundwater and provides perennial base flow in the river. The flow in the river is disrupted at Foster Park due to subsurface diversions and groundwater extraction. However, the river flow below Foster Park to the estuary increases due to effluent discharges from the Ojai Valley WWTP.

2. PROBLEM IDENTIFICATION

This section provides an overview of the impairments of the Ventura River Estuary and Ventura River by nutrients and related effects. Subsection 2.1 provides background information on nutrient enrichment. Subsection 2.2 presents the numeric and narrative water quality objectives and beneficial uses applicable to the Ventura River and Estuary. Subsection 2.3 provides a review of the information used by the Regional Board to list the Ventura River and Estuary, San Antonio Creek and Cañada Larga for algae, eutrophic conditions, nitrogen, and low dissolved oxygen. Additional data, where available, were used to assess the current condition of the waterbodies.

2.1 Nutrient Enrichment Problems in Rivers & Estuaries

Nutrients, including nitrogen (N) and phosphorus (P), are essential for plant growth and are often important limiting nutrients in aquatic environments. However, in situations of nutrient enrichment, the nutrients N and P are no longer limiting; in fact, they are readily available in the waterbody, which causes an increase in primary production and eutrophication. Eutrophication is defined by increased nutrient loading to a waterbody and the subsequent ecological response. Accelerated input of nutrients into rivers and estuaries leads to degraded waterbody conditions. Symptoms of eutrophication in rivers and estuaries are listed below.

- Increased algal biomass (macroalgae and phytoplankton)
- Reductions in dissolved oxygen (hypoxia)
- Alterations in algal species composition
- Alterations in food resources and habitat structure
- Harmful algal blooms

The relationship between nuisance algae growth and nutrient enrichment in creek and stream systems has been well-documented in the literature (Dodds and Welch, 2000; Biggs, 2000; Busse et al., 2006). Eutrophication and nutrient enrichment problems rank as one of the top causes of impairment to the nation's waters (EPA Rivers Criteria tech guide 2000 and NOAA Estuary report 1999). The problems associated with these impacts can range from a recreational nuisance to serious aquatic life and public health concerns. For example, high amounts of algal biomass and other aquatic plants interfere with swimming or wading, angling, and/or aesthetic enjoyment of the waterbody and impair the recreational beneficial uses. The aquatic life impacts of eutrophication can include fish kills, lowered fishery production, loss or degradation of important habitats (e.g. seagrass, cobble/gravel niche space), and smothering of benthic organisms (NOAA 1999 and EPA CADDIS).

There are many complex ways in which excess nutrient loads can impact beneficial uses. The conceptual models in Figures 2-1 and 2-2 outline the interactions between nutrients and biological responses in streams and estuaries, respectively. There are numerous overlapping physical, chemical, and biological factors that affect how a waterbody responds to increased nutrient loading. For example, nutrients, temperature, and light often interact together and influence processes within the aquatic ecosystem. The models below work to demonstrate the interaction and influence of various factors and to assess pathways that are contributing to the impairment of beneficial uses.

Increased nutrient loading into the stream can result in increased algal growth (Figure 2-1). The high levels of algal biomass through respiration (consumption of oxygen and production of carbon dioxide) and photosynthesis (consumption of carbon dioxide and production of oxygen) can cause significant increases in diurnal dissolved oxygen (DO) and pH swings and result in decreased overall DO (Welch and Jacoby 2004, Anderson and Carpenter, 1998). Streams impacted by high levels of algal biomass will often demonstrate supersaturated DO concentrations and high pH values in late afternoon and minimum DO and pH values in early morning (Anderson Carpenter, 1998). Low overnight DO concentrations can have considerable negative impacts on fish and in extreme cases the overnight low DO concentrations can be lethal for fish.

Adequate concentrations of dissolved oxygen are critical for the survival of fish and cold water fishes like steelhead have even greater oxygen requirements as compared to warm water fish. Decreased oxygen levels will increase the physiological stress of fish because their metabolic demands are not being met. This can impact growth and development at different steelhead life stages including eggs, alevins, and fry, as well as the swimming, feeding, and reproductive ability of juvenile and adult fish (Carter, 2005, Bjornn and Reiser, 1991).

2.1.1 Risk Cofactors for Rivers

The combination of increased nutrient loading and other factors, referred to as “cofactors”, together cause impacts (i.e. elevated algal growth, decreased DO, high pH), which lead to beneficial use impairments. The risk cofactors, in conjunction with nutrient loads, contribute to the degraded conditions manifested by the Ventura River watershed. Risk cofactors include light, temperature, flow, and canopy cover. Key cofactors in the Ventura River system are discussed below.

Riparian habitat serves several functions in stream systems including, providing shade and moderating water temperature. Riparian areas also serve to stabilize banks, prevent erosion and add to overall stream channel complexity through inputs of woody debris and aid in pool formation (Ventura River Steelhead Restoration Plan, 1997). Reductions in riparian habitat have associated reductions in shade and increased water temperatures, which promotes the growth of algae and influences changes in DO and pH. Furthermore, channel alterations including erosion, straightening, and hardening prevent the river from maintaining productive stable stream banks and disconnect the river from riparian habitat thereby preventing an important riparian function - filtering runoff.

Also, decreased flow conditions are more susceptible to high temperatures and low DO and long time periods between scour events.

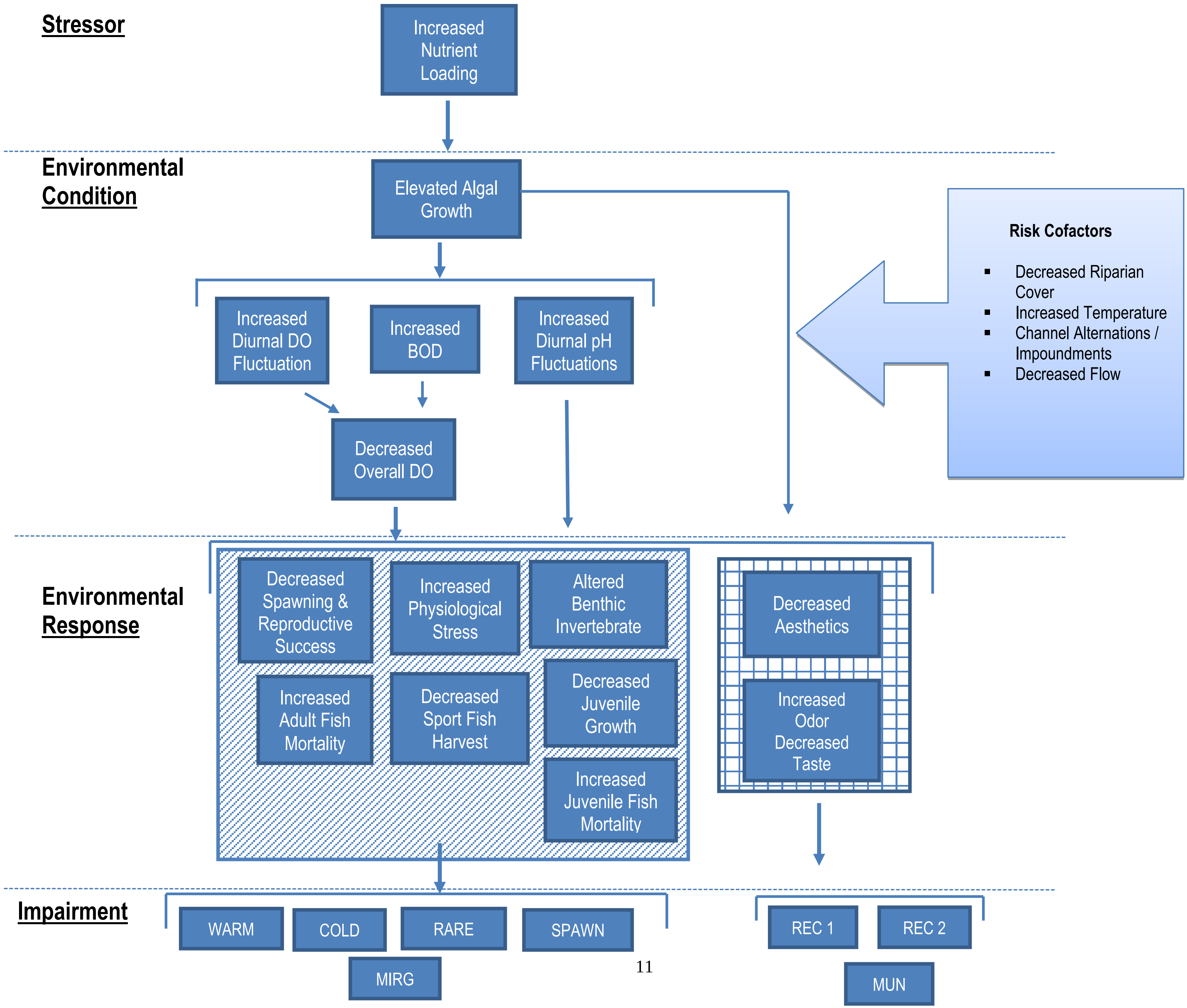

Figure 2-1 Conceptual Model for Rivers

Similar to river systems the immediate response to increased nutrient loading in estuaries is increased algal growth and potential changes in the primary producer community (Figure 2-2). As nutrient levels increase, the shallow subtidal conditions become more favorable for epiphytes (algae growing on the surface of other aquatic plants), and/or macroalgae. In deeper estuaries, phytoplankton biomass increases. This increased algal biomass (i.e. available organic matter) has effects on the biogeochemical cycling in the estuary's sediments and water. These effects include increased respiration in the sediment and water, greater frequency and duration of low dissolved oxygen conditions, and increased ammonium and sulfide in sediment pore water. The poor habitat conditions cause negative impacts on benthic organisms and higher level consumers including other invertebrates, fish, and birds (Green, 2011).

Risk Cofactors for Estuaries

There are also cofactors for estuaries that influence how the waterbody responds to increased nutrient loading and the potential risk of beneficial use impairment. These co-factors include light, temperature, mixing, and residence time. For example, estuaries with lower residence time and more frequent flushing generally accumulate less organic matter and maintain sufficient oxygen levels. Also, the effects of nutrient loading on macroalgal cover and biomass are strongly influenced by the hydrologic connection between the estuary and ocean (Sutula, 2011). Estuaries perennially connected to the ocean are expected to have decreased effects (i.e. changes to water and sediment physiochemical parameters) from macroalgae because these effects generally decrease with increased water depth. However, intertidal and shallow subtidal areas are more likely to be affected by macroalgae mats because there is a greater amount of algal biomass relative to the volume of water (Sutula, 2011). Finally, as in rivers, the availability of light and increased water temperatures promotes algal growth, which can influence changes in estuary oxygen and pH.

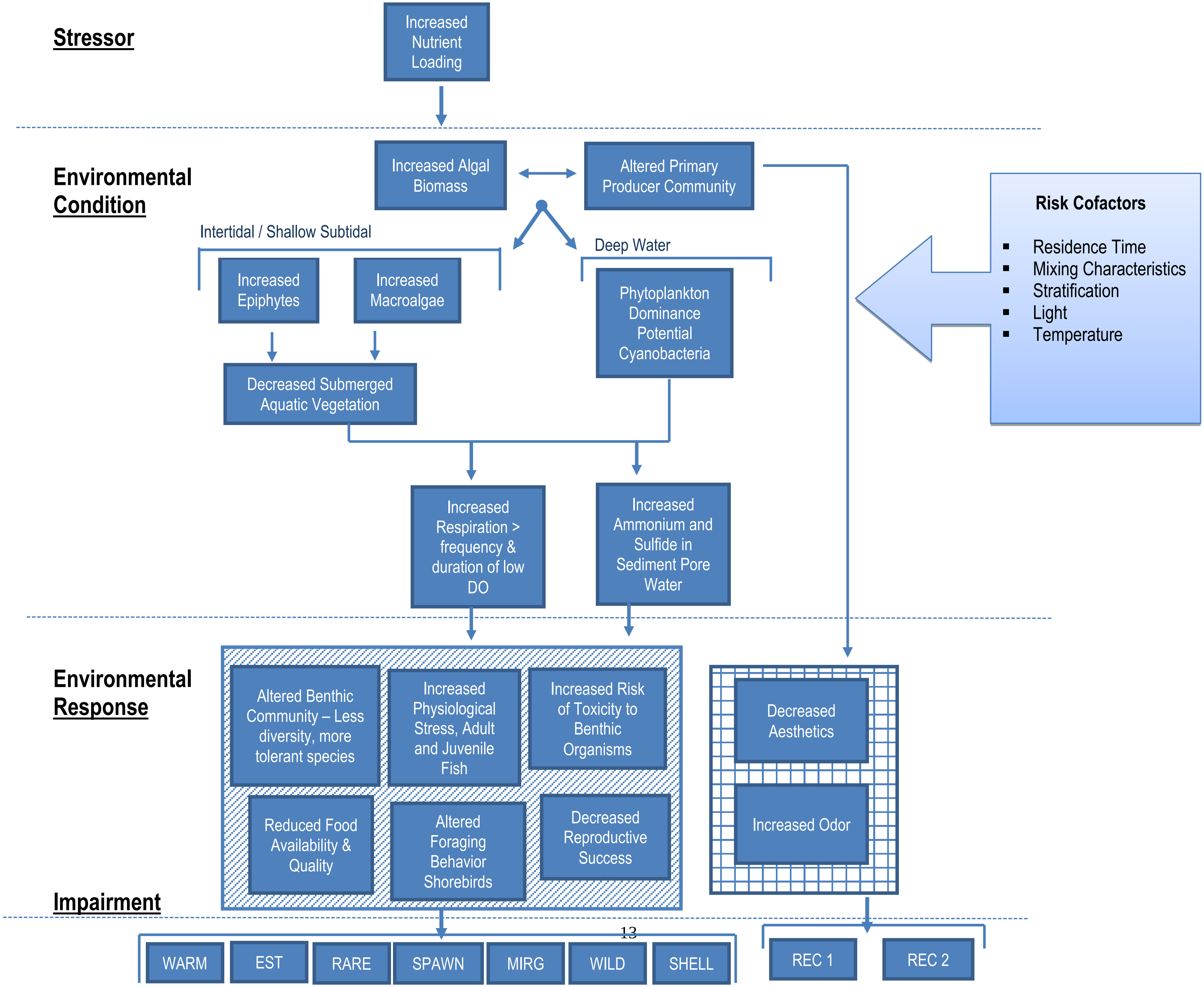

Figure 2-2 Conceptual Model for Estuaries

2.2 Water Quality Standards

California water quality standards consist of the following three elements: 1) beneficial uses, 2) narrative and/or numeric water quality objectives, and 3) an antidegradation policy. In California, beneficial uses are defined by the regional boards in their Water Quality Control Plans (Basin Plans). Narrative and numeric objectives are designed to be protective of the beneficial uses specified in the Los Angeles Region Basin Plan.

2.2.1 Beneficial Uses

The Basin Plan for the Los Angeles Regional Board (LARWQCB, 1994) defines twenty (20) beneficial uses for Ventura River and Ventura River Estuary (Table 2-1). These beneficial uses are recognized as existing (E), potential (P) or intermittent (I) uses. Nutrient loading and the resulting ecological responses in Ventura River and the estuary may result in impairments of beneficial uses associated with recreation (REC1 and REC2), aquatic life (WARM, COLD, EST, WILD, RARE, MIGR, SPWN, and WET), and water supply (MUN).

The most sensitive beneficial use in the Ventura River watershed is the cold water aquatic habitat (COLD) use and the associated migratory (MIGR) and spawning and early development (SPWN) uses. The Ventura River and its tributaries is home to the Southern California Steelhead, which was first recognized as endangered by the NOAA National Marine Fisheries Service (NMFS) in 1997. It status as endangered was reaffirmed in 2006. According to NMFS, the total population of the Southern California Steelhead has dropped from 32,000-46,000 spawning adults to less than 500 (NOAA 2012). The Ventura River, Ventura River Estuary, San Antonio Creek, Canada Larga, Matilija Creek and North Fork Matilija Creek among other tributaries have been designated by NMFS as critical habitat for the remaining population of the Southern California Steelhead.

The municipal and domestic supply (MUN) use designation applies to Ventura River Reaches 1 and 2, Canada Larga, and Matilija Creek as a potential (P) beneficial use. This beneficial use, for Ventura River and its tributaries, is indicated with an asterisk in the Basin Plan as a conditional use. Conditional designations are not recognized under federal law and are not water quality standards requiring TMDL development at this time. (See Letter from Alexis Strauss [US EPA] to Celeste Cantú [State Board], Feb. 15, 2002)

Table 2-1 Beneficial Uses of the Ventura River Watershed

Watershed	MUN	IND	PROC	AGR	GWR	FRSH	NAV	REC1	REC2	COMM	WARM	COLD	EST	MAR	WILD	RARE	MIGR	SPWN	SHELL	WET
Ventura River Estuary							E	E	E	E	E		E	E	E	Ee	Ef	Ef	E	E
Ventura River R 1	P*	E		E	E	E		E	E		E	E			E	E	E	E		E
Ventura River R 2	P*	E		E	E	E		E	E		E	E			E	E	E	E		E
Ventura River R 3	P*	E		E	E	E		E	E		E	E			E	E	E	E		E
Ventura River R 4	E	E	E	E	E	E		E	E		E	E			E	Eg	E	E		E
Ventura River R 5	E	E	E	E	E	E		E	E		E	E			E	Eg	E	E		E
Cañada Larga	P*		I	I	I	I		I	I		I	I			E		I	I		
San Antonio Creek	E	E	E	E	E			E	E		E	E			E		E	E		E
San Antonio Creek (above Lion Creek)	E	E	E	E	E	E		E	E		E	E			E		E	E		E
Matilija Creek	P*				E			E	E			E			E		E	E		E
North Fork Matilija Creek	E*	E	E	E	E			E	E		E	E			E	E	E	E		E

2.2.2 Water Quality Objectives

The Basin Plan specifies narrative and numeric objectives, which both apply to Ventura River and Ventura River Estuary. The following narrative objectives apply to this TMDL.

Biostimulatory Substances: *Waters shall not contain biostimulatory substances in concentrations that promote aquatic growth to the extent that such growth causes nuisance or adversely affects beneficial uses.*

Taste and Odor: *Waters shall not contain taste or odor producing substances in concentrations that impart undesirable tastes or odors to fish flesh or other edible aquatic resources, cause nuisance, or adversely affect beneficial uses.*

The numeric water quality objects applicable to this TMDL are listed below.

Dissolved Oxygen (DO): *At a minimum the mean annual DO concentrations of all waters shall be greater than 7.0 mg/L, and no single determinations shall be less than 5.0 mg/L except when natural conditions cause lesser concentrations.*

The dissolved oxygen content of all surface waters designated as both COLD and SPWN shall not be depressed below 7 mg/L as a result of waste discharges.

pH: *The pH of inland surface waters shall not be depressed below 6.5 or raised above 8.5 as a result of waste discharges. Ambient pH levels shall not be changed more than 0.5 units from natural conditions as a result of waste discharge.*

The pH of bays or estuaries shall not be depressed below 6.5 or raised above 8.5 as a result of waste discharges. Ambient pH levels shall not be changed more than 0.2 units from natural conditions as a result of waste discharge.

Ammonia: *In order to protect aquatic life, ammonia concentrations in inland freshwaters shall not exceed the values calculated for the appropriated in-stream conditions shown in tables 3-1 to 3-3 in the Basin Plan.*

For inland surface waters not characteristic of freshwater the four-day average concentration of un-ionized ammonia shall not exceed 0.035 mg/L and the one-hour average concentration shall not exceed 0.233 mg/L.

Determination of Freshwater, Brackish Water or Saltwater Conditions
For inland surface waters in which the salinity is equal to or less than 1 part per thousand 95% or more of the time, the applicable objectives are the freshwater objectives, based on the US EPA "1999 Update of Ambient Water Quality Criteria for Ammonia." (2) For waters in which the salinity is equal to or greater than 10 parts per thousand 95% or more of the time, the applicable objectives are a 4-day average concentration of 0.035 mg un-ionized NH3/L and a one-hour average concentration of 0.233 mg un-ionized NH3/L. (3) For waters in which the

salinity is greater than 1 but less than 10 parts per thousand, the applicable objectives the more stringent of the freshwater or saltwater objectives.

Nitrogen: *Waters shall not exceed 10 mg/L nitrogen as nitrate-nitrogen plus nitrite-nitrogen (NO3-N + NO2 – N), 45 mg/L as nitrate (NO3), 10 mg/L as nitrate-nitrogen (NO3-N) or 1 mg/L as nitrite-nitrogen (NO2-N) or as otherwise designated in Table 3-8.*

Basin Plan Table 3-8 presents the nitrogen objective for Ventura River Reaches 5,4,3, and 2 as 5mg/L. This limit also applies to Cañada Larga and San Antonio Creek as tributaries to Reaches 2 and 4, respectively.

This nitrogen objective is established for the protection of the MUN beneficial use and objectives in Table 3-8 are waterbody specific. As presented in the problem identification and water quality assessment sections of this document, the numeric objective of 10 mg/L and the waterbody specific objective 5 mg/L is not sufficiently protective to control excessive algal growth and eutrophic conditions in the river and estuary and thus protect the most sensitive beneficial use in the watershed, which is aquatic life. Current nitrate loading in the watershed is a contributor to the exceedence of the biostimulatory substances narrative objective. Therefore, this TMDL will set numeric targets and allocations at levels necessary to attain the biostimulatory substances objective and protect all beneficial uses.

2.2.3 Antidegradation

State Board Resolution 68-16, “Statement of Policy with Respect to Maintaining High Quality Water” in California, known as the "Antidegradation Policy," protects surface and ground waters from degradation. Any actions that can adversely affect water quality in all surface and ground waters must be consistent with the maximum benefit to the people of the state, must not unreasonably affect present and anticipated beneficial use of such water, and must not result in water quality less than that prescribed in water quality plans and policies. Furthermore, any actions that can adversely affect surface waters are also subject to the federal Antidegradation Policy (40 CFR 131.12). The proposed TMDL will not degrade water quality, and will in fact improve water quality as it is designed to achieve compliance with existing water quality standards in order to ensure that beneficial uses of the Ventura River system are fully supported.

2.3 Water Quality Data Summary

This section presents a review of the data used by the Los Angeles Regional Board to identify reaches of the Ventura River and Estuary, San Antonio Creek, and Cañada Larga as impaired by algae, eutrophic conditions, nitrogen, and low dissolved oxygen. Additional data, where available, were also used to assess the current condition of the waterbodies.

2.3.1 Basis for 303(d) Listings

The basis for the algae and eutrophic condition impairments in Ventura River Reach 1 and 2 and the estuary was the 1996 Water Quality Assessment (WQA) conducted by Regional Board. There is limited information available regarding these listings; however, the information that is available is summarized below.

As part of the 1996 WQA, Regional Board staff conducted field surveys that included observations of algae during the summer season. The field logs used in this work included qualitative observations of algae. A standard field log worksheet, developed by Regional Board staff, was used to summarize observations made during sampling events. The worksheet directed staff to evaluate algal cover ranging from zero to dense (> 50% cover) and floating versus attached algae. The worksheet results were compiled and waterbodies were characterized as impaired or attaining beneficial uses.

San Antonio Creek is listed for nitrogen on the 2002 303(d) list. The fact sheet (2002 CWA 303(d) List Staff Report, 2003 page 4-198) presents the staff recommendation of listing this waterbody due to greater than 10% exceedances of the applicable nitrogen objectives of 5 mg/L. Similarly, Cañada Larga was identified as impaired and placed on the 2002 303(d) list for greater than 10% exceedances of the dissolved oxygen objective (2002 CWA 303(d) List Staff Report, 2003 page 4-78).

2.3.2 Assessment of Current Water Quality Data

Staff has evaluated data from various sources including those listed below.

- Regional Board funded contracts, University of California, Santa Barbara Study
- Ojai Valley Sanitation District receiving water monitoring
- Santa Barbara Channel Keeper (SBCK), Ventura Stream Team
- Ventura County Watershed Protection MS4 monitoring
- Southern California Stormwater Monitoring Coalition (SMC)
- Regional Board Surface Water Ambient Monitoring Program (SWAMP)

<u>Dissolved Oxygen</u>

The photosynthetic and respiration activities of algae can drive significant changes in DO concentrations over a 24-hour period. In fact, when algae are abundant they can act as the most significant influence on the magnitude of diurnal oscillations in dissolved oxygen concentrations (Wetzel, 2001). Considering algal respiration and photosynthesis separate from other factors (e.g. water turbulence, water depth, and temperature), nighttime respiration reduces dissolved oxygen until the daytime activity of photosynthesis reverses the process and produces oxygen. However, other physical factors including temperature, turbulence, and water depth also work to incorporate oxygen from the atmosphere into the water. These physical processes mediate declining nighttime oxygen concentrations.

The graph below (Figure 2-3) summarizes the pre-dawn dissolved oxygen measurement made by the SBCK during the growing season from 2008 through 2011. The pre-dawn measurements of dissolved oxygen are not the exact minimum oxygen concentration in the river because of physical factors also influencing the amount of oxygen in the river. However, the pre-dawn measurements provide a very reasonable estimate of the minimum dissolved oxygen observed during a 24-hour period. Two noteworthy elements of this figure are that 1) sites in the upper watershed (Matilija above the dam and North Fork Matilija) express pre-dawn DO concentrations below the 7 mg/L water quality objective less frequently than sites in the middle and lower parts of the watershed and 2) all sites demonstrate interannual variability most likely related to the magnitude of algal growth and flow conditions.

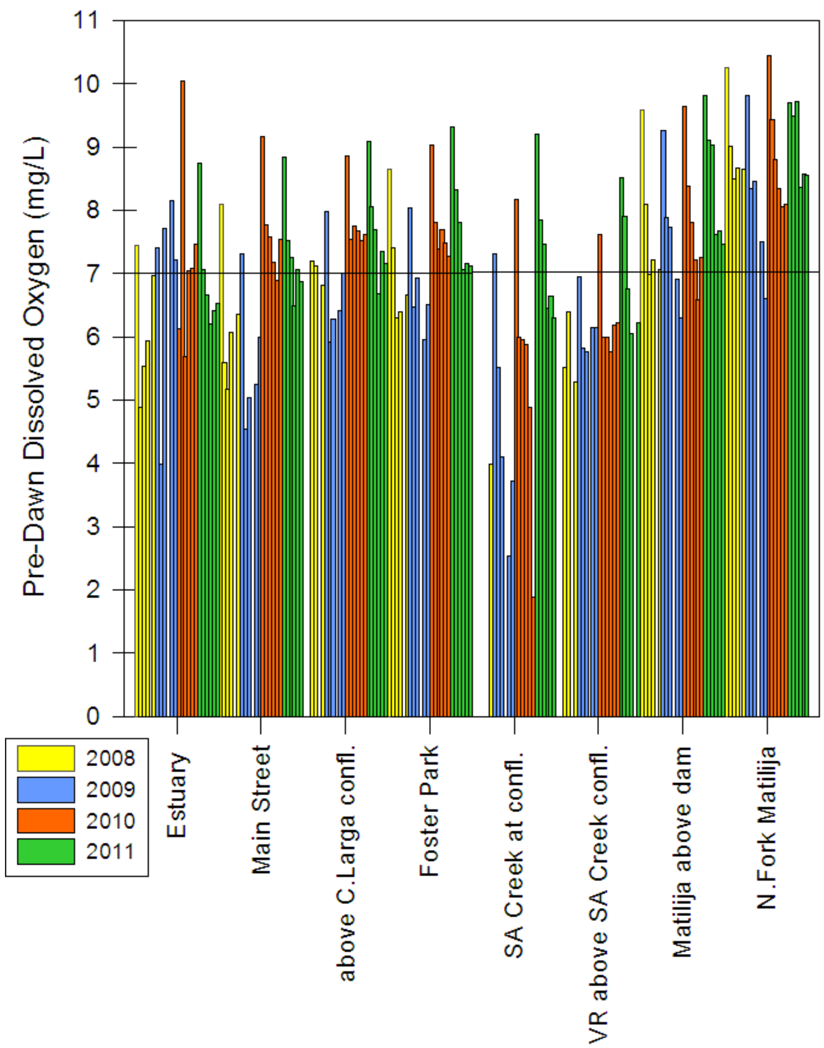

Figure 2-3 Pre-dawn dissolved oxygen measurements during the growing season, 2008 through 2011

Figures 2-4 – 2-10 present the difference between pre-dawn and afternoon DO measurements at strategic locations in the watershed. These figures show more clearly the influence of algal biomass on daily dissolved oxygen concentrations. The pre-dawn measurements represent the daily minimum concentration when nighttime respiration processes have reduced oxygen concentrations. The afternoon measurement captures the daily maximum concentration when photosynthesis leads to super saturated conditions.

The most dramatic oxygen depletion events occurred on San Antonio Creek in the late summer months (Figure 2-7). It is likely that low flow conditions contributed to the depleted oxygen condition. The minimum stream oxygen concentration is proportional to the amount of algal biomass present in the river – greater amount of algal biomass, the greater amount of oxygen removed during nighttime respiration. However, it is also inversely proportional to the amount of flow – a greater flow mitigates the impact of algal respiration on DO because it is more difficult and requires larger amounts of algae to effect large volumes of flowing water. The flow in San Antonio Creek at the confluence of Ventura River typically decreases to approximately 1 cfs by late summer (SBCK flow data).

A less extreme example was observed in the upper watershed at Matilija Creek (Figure 2-9); the lowest DO measurement was consistently observed in late summer when flows were at the lowest (~ 1 – 3 cfs). In contrast to the upper watershed and tributary areas, the lower watershed sites (Main Street and estuary) expressed low DO concentrations earlier in the summer aligned with maximum algal biomass growth. Extreme low flow conditions were prevented by discharge from the Ojai Valley WWTP (Figure 2-4 and 2-5).

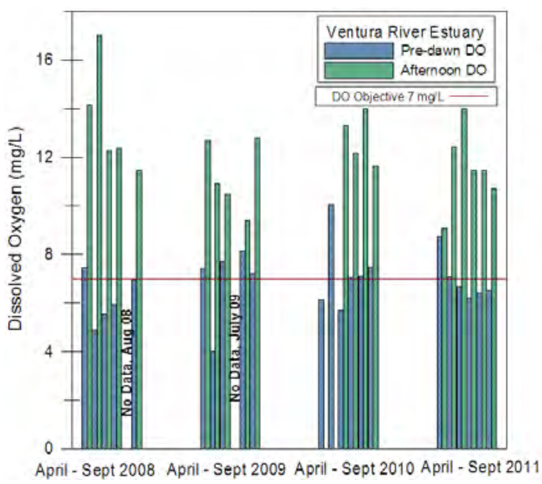

Figure 2-4 Estuary DO Measurements

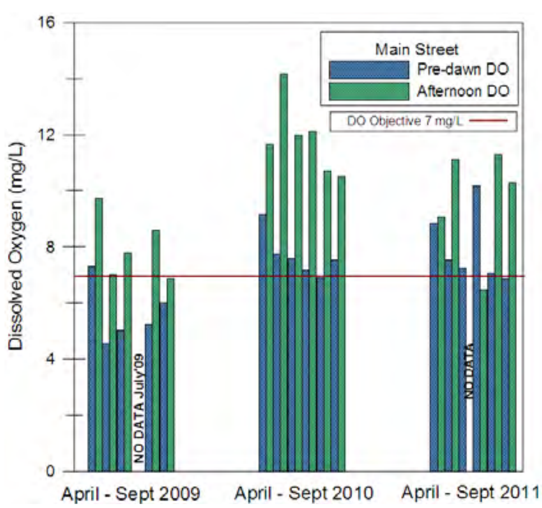

Figure 2-5 Main Street DO Measurements

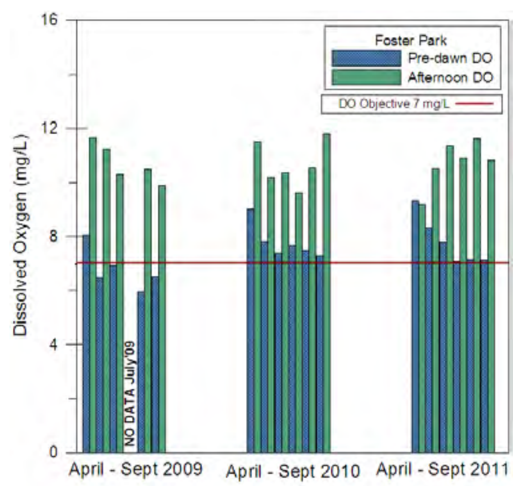

Figure 2-6 Foster Park DO Measurements

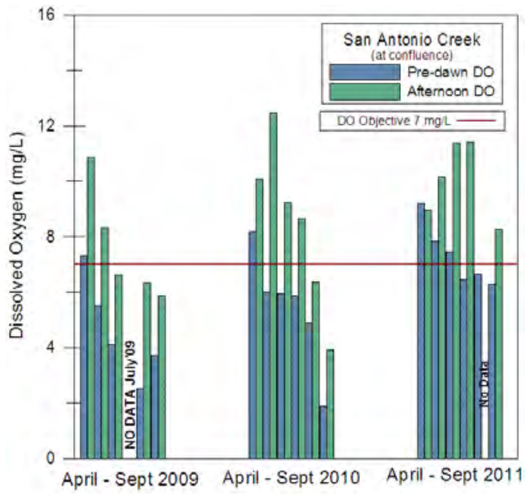

Figure 2-7 San Antonio Creek DO Measurements

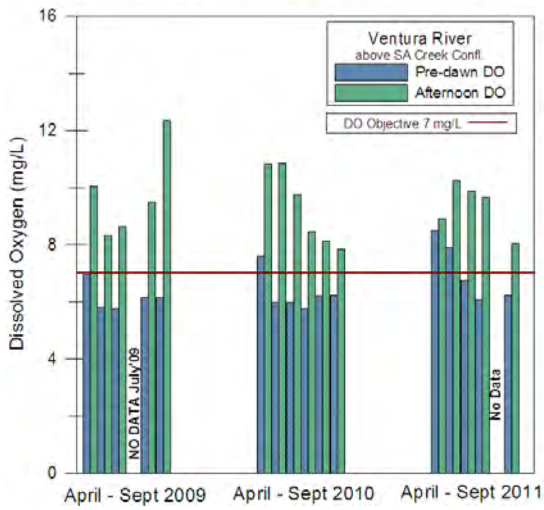

Figure 2-8 Ventura River above San Antonio Creek A Creek DO Measurements

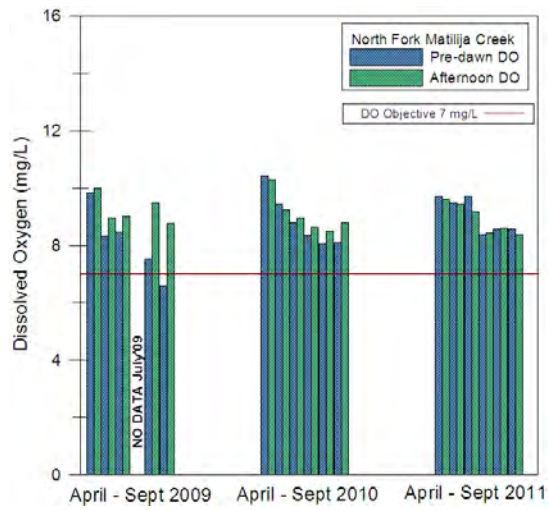

Figure 2-10 North Fork Matilija Creek Do Measurements

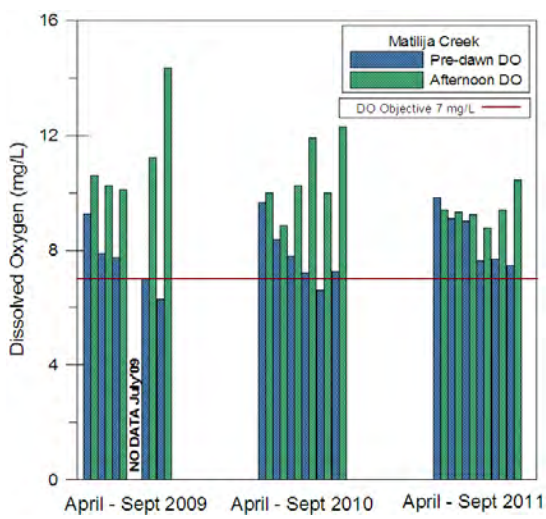

Figure 2-9 Matilija Creek DO measurements

As can been seen from these graphs and the data in Appendix A, DO concentrations below the water quality objectives are repeatedly observed during the summer months. The SBCK pre-dawn DO data was assessed in accordance with the SWRCB *Policy for Developing California's Clean Water Act Section 303 (d) List* to evaluate potential DO impairments. The following stream locations were identified as impaired.

- Ventura River Estuary
- Ventura River at Main Street
- Ventura River above Cañada Larga confluence
- Ventura River at Foster Park
- Ventura River above San Antonio Creek confluence
- San Antonio Creek at confluence with Ventura River
- Lower San Antonio Creek
- Upper San Antonio Creek
- Pirie Creek (tributary to San Antonio Creek)

The DO objective of 7 mg/L was applied in this assessment to be protective of the COLD and SPWN beneficial uses. This objective was also applied to estuary because the estuary is designated with both SPWN and MIGR beneficial uses and endangered Southern California steelhead trout are present in this watershed.

<u>Nutrients</u>

The nutrient concentrations measured in-stream by SBCK demonstrate seasonal patterns with an expected amount of variability. Nitrogen, presented as nitrate in the figures below, generally peaks in the winter months as it is mobilized by winter storms and then begins to decline as it is taken up by algae and plants through the growing season. The sites Ventura River at Foster Park and Main Street (Figure 2-11 and 2-12) are a well-defined examples of this seasonal cycle; the variation in winter nitrogen peaks are related to the amount of rainfall in any given year and concentrations decline near zero during the prime growing season. A notable exception to this pattern is the increased nitrate concentration in San Antonio Creek in late spring and early summer 2001, 2005, and 2011. Based on the analysis presented in Nutrient Concentrations in the Ventura Watershed: 2008-2011 (Leydecker, March 2012), this nitrate increase is related to groundwater recharge with high nitrate waters in the upper San Antonio Creek drainage area.

Additionally, Ventura River at Shell Road and Ventura River above the Cañada Larga confluence exhibit a slightly different pattern. These sites are approximately 1.9 and 0.45 miles downstream of the Ojai Valley WWTP, respectively, and the in-stream nitrate concentrations reflect the continual nutrient inputs from the treatment plant. For example, seasonal peaks in concentration occur in late summer/early fall as discharge from the treatment plant increasingly dominates the flow in the river.

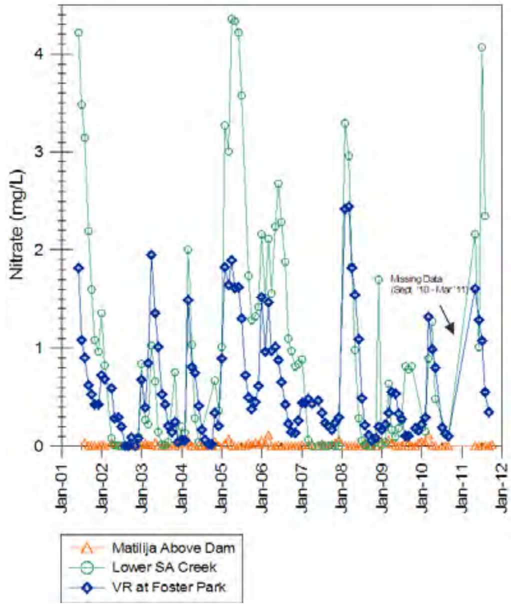

Figure 2-11 Nitrate Concentration Upper Watershed

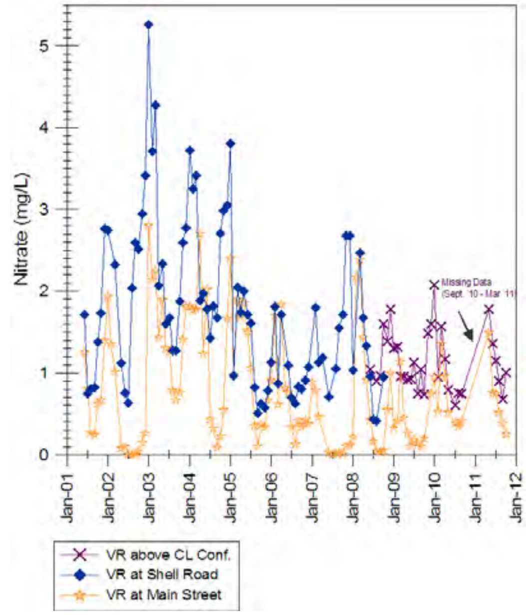

Figure 2-12 Nitrate Concentration lower watershed

Phosphate concentrations in the upper watershed (Matilija Creek) are generally measured as zero or nondetect with very slight increased concentrations (0.01 – 0.02) observed during the winter. The data from Ventura River at Foster Park show similar results albeit with slightly higher winter time increases (~0.01 – 0.03). Although, samples collected in November 2009 show a marked spike to approximately 0.1 mg/L phosphate. Phosphate concentrations measured below the treatment plant (Ventura River at Shell Road and above Cañada Larga confluence) exhibit increased dry season concentrations as the discharge accounts for the majority of flow. Phosphate measured at Main Street appears to follow the pattern of upstream measurements, but report slightly lower concentrations reflecting the biological uptake and processing between the sites.

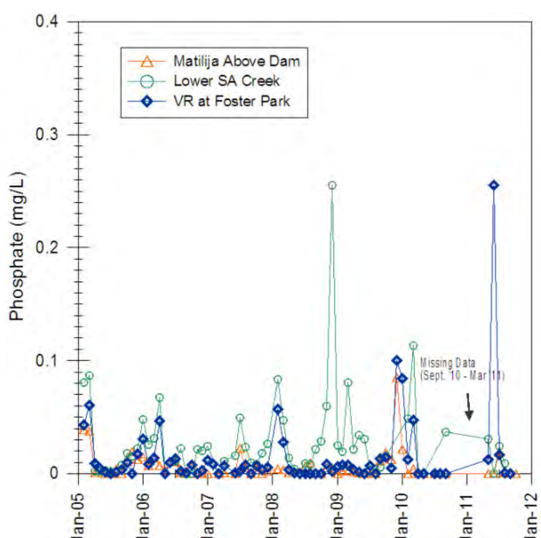

Figure 2-13 Nitrate Concentration Upper Watershed

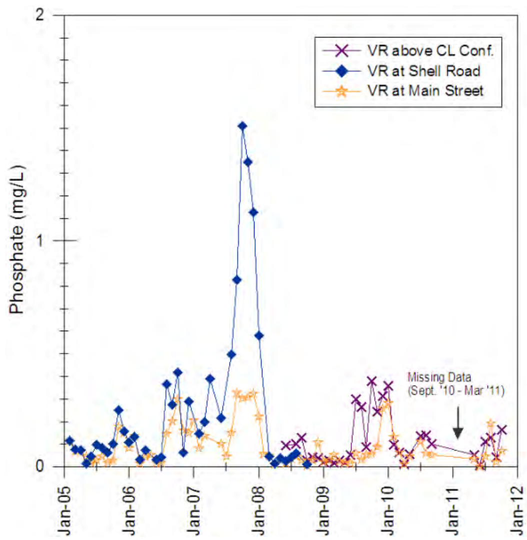

Figure 2-14 Nitrate Concentration Lower Watershed

As discussed above, in the late summer discharge from the WWTP dominates the flow in the lower portion of the watershed (Reaches 1 and 2). Thus, the in-stream nutrient concentrations largely reflect nutrients discharged from the plant. Over the years due to treatment upgrades and improved plant performance the amount of nitrogen discharged from the treatment plant has dramatically reduced. Figure 2-15, presents the effluent Total Inorganic Nitrogen (TIN) concentrations from treatment plant over time (Jan. 1979 – Dec 2011).

Through the mid-1990s, the plant operated with advanced secondary treatment including nitrification to oxidize ammonia, but not denitrification to reduce nitrate to nitrogen gas. Thus, the plant's discharge contained large amounts of nitrogen; the graph presents an average TIN effluent concentration of approximately 20 mg/L from the 1980s through the mid 1990s. In the summer of 1996 the OVSD completed plant upgrades including denitrification and tertiary treatment, the result the improved treatment is clearly seen on the graph. The average effluent TIN concentration was reduced to 5 mg/L; a 75 percent reduction. Decreased in-stream nitrate concentrations also reflect improvements at the treatment plant (Figure 2-16). Prior to the upgrades in 1996 the average nitrate concentration approximately 1,000 yards downstream was 9.5 mg/L and after the upgrade the average in-stream concentration was 2.4 mg/L.

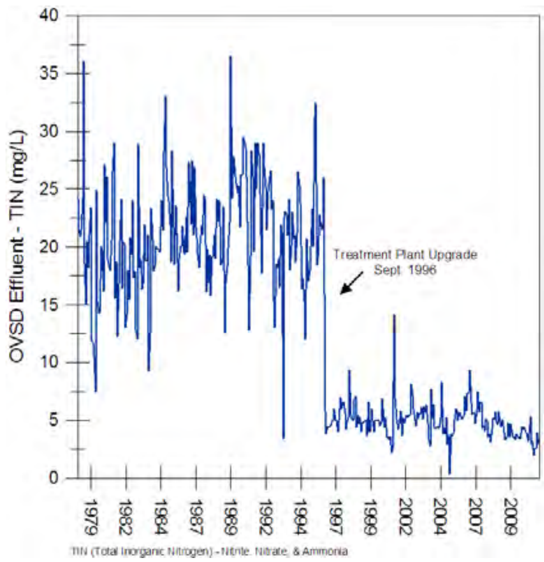

Figure 2-15 OVSD Effluent TIN Concentration 1979-2009

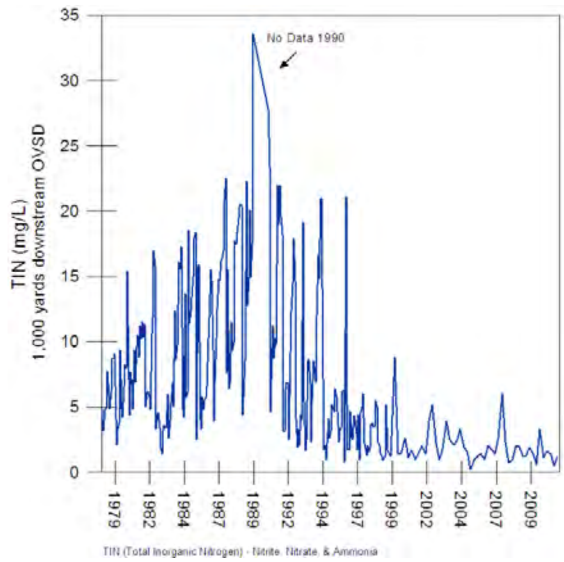

Figure 2-16 Ventura River TIN Concentration Downstream OVSD 1979-2009

<u>Algal Biomass</u>

Benthic and macroalgae (total algal biomass) can be found throughout the Ventura River watershed. In 2008 as part of a Regional Board contract the University of California, Santa Barbara measured algal biomass at targeted locations in the watershed. Sites were selected to provide a gradient of development and land use in the watershed. Each site was sampled twice, once in early summer (June 2008) and once in late summer (September 2008). Figure 2-17 below presents a watershed map and bar graphs of the total algal biomass results. Algal biomass in the upper watershed was quite low over both months (<60 mg/m^2). In the middle portion of the watershed (approximately San Antonio Creek to Foster Park) there was a marked difference in biomass present in June versus September and concentrations were considerably greater as compared to the upper watershed sites. In June 2008 biomass measured in the middle watershed ranged from approximately 200 – 400 mg/m^2; by September biomass levels had declined and ranged from 90 – 150 mg/m^2. The highest algal biomass concentrations were reported in the lower watershed below the wastewater treatment plant. The maximum concentration was in the Ventura River at Main Street, 1037 mg/m^2 in June, and the minimum concentration observed (in the lower watershed) was 225 mg/m^2 at the Shell Road site in September 2008.

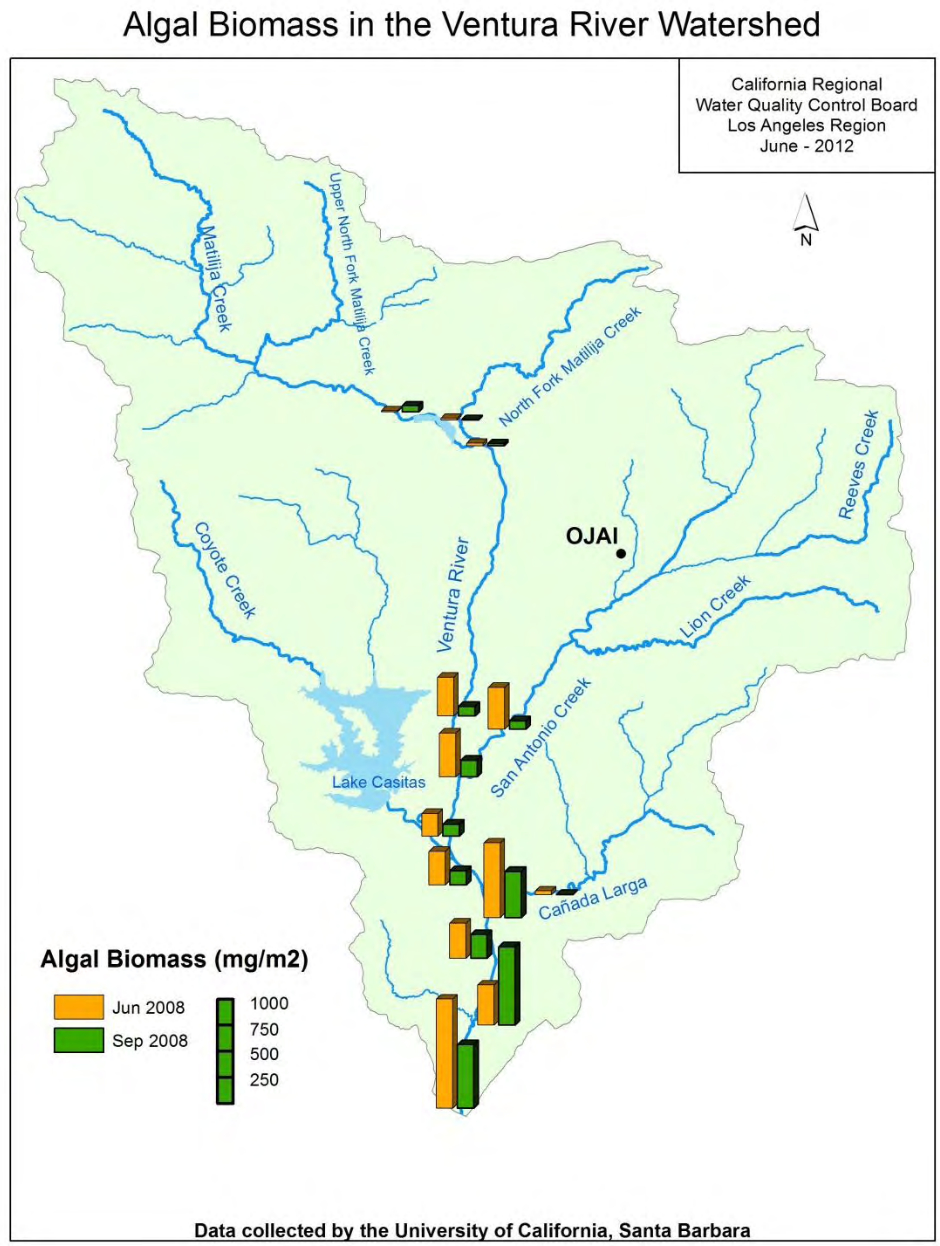

Figure 2-17 Algal Biomass Ventura River Watershed, 2008

In addition to the project conducted by UCSB, the Southern California Stormwater Monitoring Coalition (SMC) collected algal biomass data as part of the bioassessment monitoring required under the Ventura County MS4 permit. This monitoring program has a probabilistic design (i.e. random site selection and not the same sites every year) and only samples sites in spring to early summer because this timeframe coincides with the index period (spring to early summer) for benthic macroinvertebrates sampling. Since this algae data was collected as part of a larger monitoring program the results may not capture the seasonal maximum algal biomass. However, the results do provide useful information to assess conditions and investigate algal dynamics in the watershed.

Although there are results from multiple years presented on Figure 2-18 it is best to evaluate results from the same year at different locations because the interannual variation in algal biomass can be significant. In 2008 the SMC found small (<20.0 mg/m^2) amounts of algal biomass in Upper North Fork Matilija Creek and Ventura River Reach 4. In 2009 sites in North Fork Matilija and upper Reach 4 maintained low amounts of biomass; however, the site in San Antonio Creek had higher concentration (~ 50 mg/m^2) and lower Ventura River was found to be 112 mg/m^2. Matilija Creek and Ventura River near Foster Park had similar amounts of algal biomass as measured in 2010 and in 2011; the upper tributaries and San Antonio Creek had biomass concentrations from 25 – 100 mg/m^2. In summary, different amounts of algae grow in different watershed locations and different amounts of algae grow in different years.

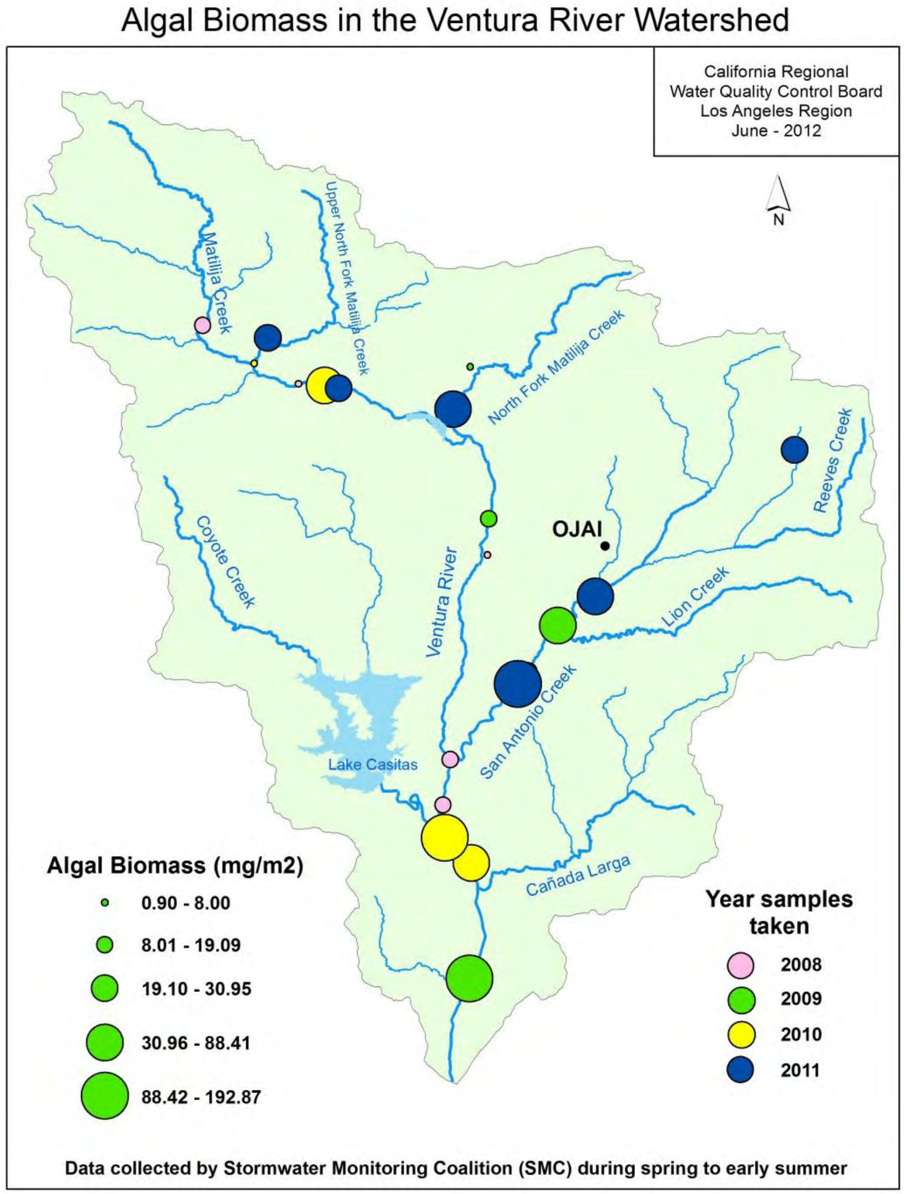

Figure 2-18 Algal Biomass Ventura River Watershed, 2008-2011

The interannual variation in algal biomass growth appears to be closely related to rainfall in the preceding year (Lydecker, 2003 and Lydecker et al., 2004). For example, large winter storms that scour the river removing plants, brush, and riparian cover change the river's physical habitat creating an open channel with available light and nutrients, which favors algae growth. The photographs below provide a dramatic example of the physical changes that can occur (photos provided by Al Lydecker). In 2004 the Ventura River at Main Street Bridge had a large amount of trees and plants established in the river channel and the open water portion of the channel was quite narrow. However, the very large winter storms of 2005 completely cleared the channel of vegetation and shifted the river's physical habitat to favor algal growth.

Figure 2-19 Main Street Bridge 2005

Overtime, during years with more typical rainfall or drought years the river channel is reclaimed by fast growing riparian trees (e.g. willows), shrubs, and various aquatic plants this once again narrows the channel, increases shading, and creates a habitat in which algae are less competitive. These changes can be observed moderately overtime, that is dramatic storm events are not the only observation of interannual variation on the river. The photos below document the succession of the channel from fairly open, favoring algal growth, to being dominated by rooted aquatic plants (Ventura River at Main Street Bridge looking upstream) (photos from Al Lydecker, Watershed U handout 2010).

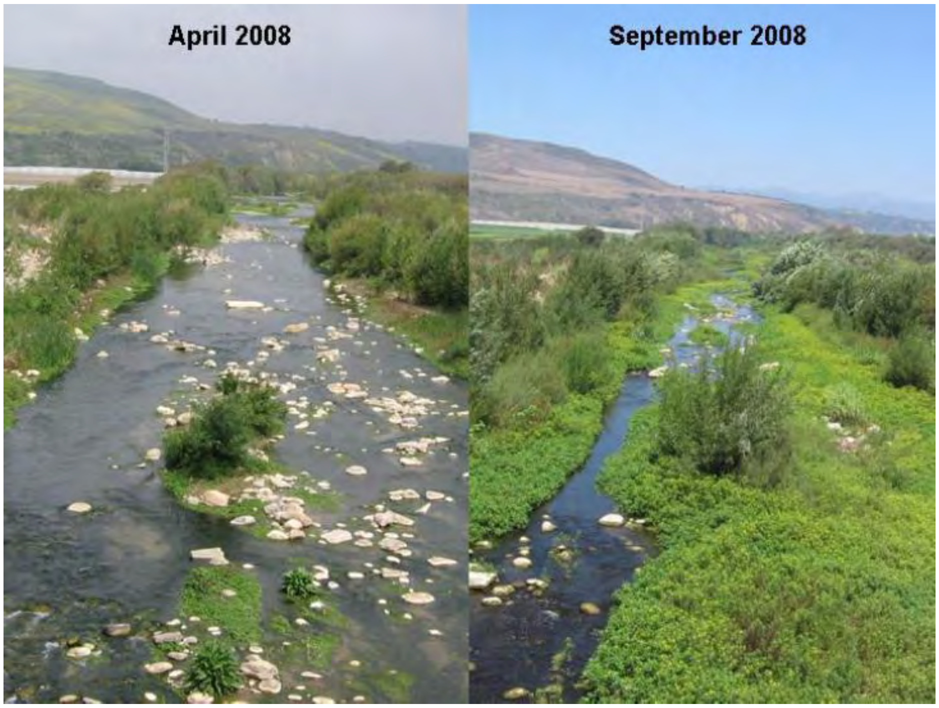

Figure 2-20 Main Street Bridge 2008

The interannual changes described above occur throughout the watershed; although not as dramatically as observed in the lower watershed. (Lydecker, 2010).

The physical changes that occur on the Ventura River due to the wet-winter dry-winter rainfall pattern impacts the ecology of the river and influences the amount algae observed from year to year (Lydecker, 2010). Because of the changing physical conditions and related cofactors it is important that the TMDL address nutrient loading to the river in addition to any watershed wide projects that may be designed to promote certain cofactors such as, increased riparian area and canopy cover.

Algal species composition is another line of evidence when evaluating stream nutrient conditions. Shifts in algal species composition can reflect changes in nutrient concentrations (US EPA, 2000b). The 2008 UCSB study evaluated algal species composition in the Ventura River Watershed (Figure 2-21). In the June sample set all sites were composed of *Cladophora* and diatoms; however, the upper watershed sites had considerably lower percentages of *Cladophora* and statistically significant higher amounts of diatoms (UCSB, 2009). By late summer diatoms and other marcoalgae genera had become more prominent that *Cladophora*. The summer time shifts in algal composition in the Ventura River have also been documented by the work of SBCK and regional expert Al Lydecker (Lydecker, 2008).

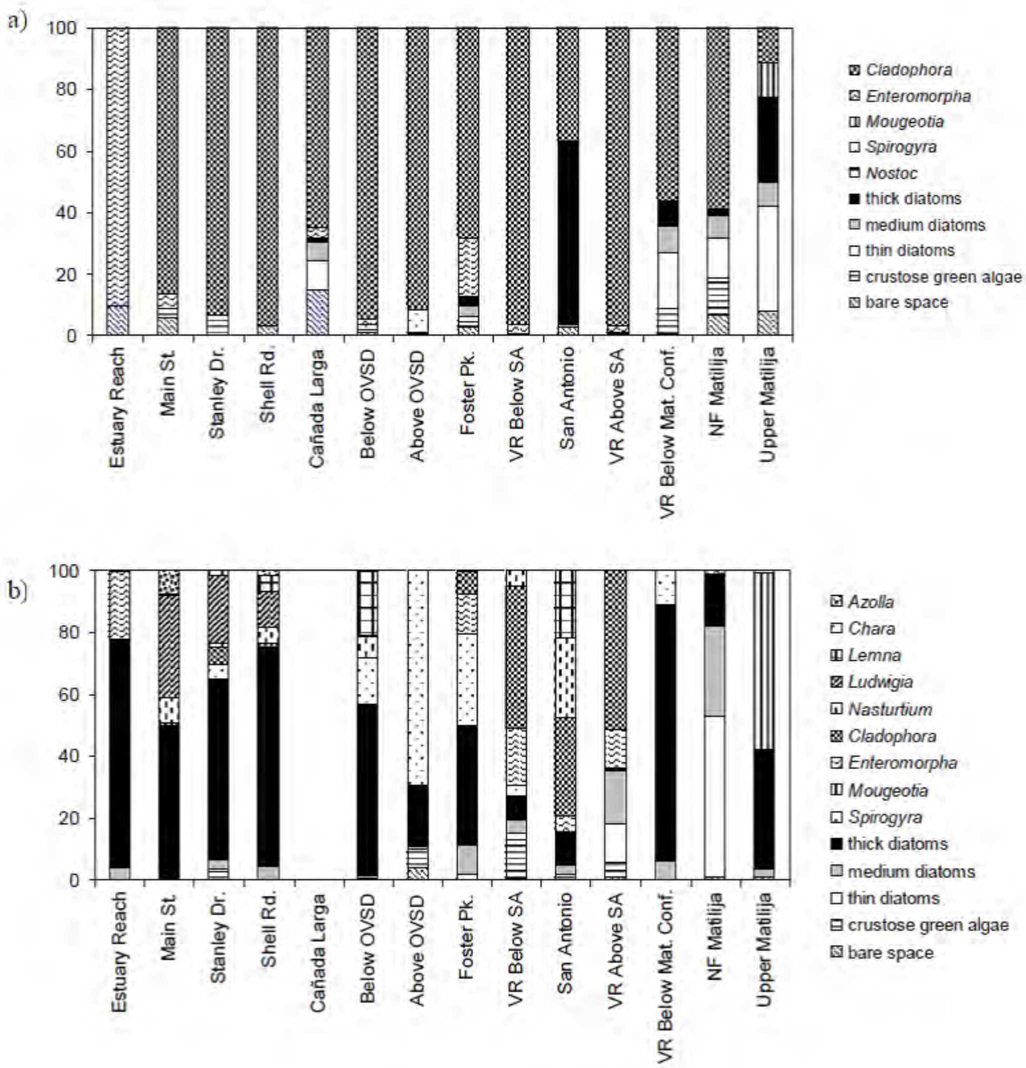

Figure 2-21 Percent Cover of Different Algal Types (UCSB, 2008)

2.4 Problem Statement

This data analysis demonstrates the water quality problems related to eutrophication and increased nutrient loading and documents the exceedance of the dissolved oxygen and biostimulatory substances water quality objectives during the growing season. The nutrient concentrations in the Ventura River and Estuary contribute to the excessive algal biomass growth, which in turn contributes to low DO conditions. The DO information presented documents repeated poor DO conditions during the growing season which contribute to multiple impacts on cold water fish, including decreased growth, increased stress, decreased reproductive success and increased juvenile and adult fish mortality. The changes in the river and estuary ecosystem degrades cold water habitat leading to impaired aquatic life and recreation beneficial uses. This TMDL will address impairments causing the growing season exceedance of the biostimulatory substances water quality objective in Ventura River, Estuary and tributaries (Table 2-2).

Table 2-2 Impairments addressed by this TMDL

Waterbody	Impairment
Ventura River Estuary	Algae, eutrophic conditions, and low DO
Ventura River Reach 1	Algae, low DO
Ventura River Reach 2	Algae, low DO
Cañada Larga	Low DO
Ventura River Reach 4	Low DO
San Antonio Creek	Nitrogen and low DO

While the nutrient concentrations present in the river during the winter months are sufficient to support algal growth, cofactors such as, flow and temperature exert greater influence on the river. Also, the typical seasonal succession of primary producers generally shifts in the winter to be dominated by aquatic plants (Al Lydecker, personal communication). The changes in cofactors and ecology minimize winter season algal growth. For example, the first significant rain event of the season will scour algae from the river and higher winter flows make it difficult for algae to recolonize. Additionally, cooler temperatures and reduced light further diminish winter season algal growth. The watershed nutrient wet-weather loads are generally delivered directly to the ocean and thus don't contribute to exceedance of the biostimulatory substances objective in the river or estuary, which occurs during the growing season.

3. NUMERIC TARGETS

The section identifies numeric targets that can be used to assess attainment of water quality objectives and the protection of beneficial uses. Multiple numeric targets may be used when a single target is not sufficient to fully evaluate attainment of water quality standards and protect beneficial uses. For the pollutants addressed by this TMDL the numeric targets are expressed as algal biomass, macroalgal percent cover, phytoplankton biomass, dissolved oxygen, and pH (Table 3-1). The DO and pH numeric targets are set equal to the numeric water quality objectives contained in Chapter 3 of the Basin Plan and the numeric targets for algal and phytoplankton biomass and cover are established as a numeric interpretation the water quality condition that will demonstrate attainment of the water quality condition that will attain the narrative water quality objective for biostimulatory substances contained in Chapter 3 of the Basin Plan.

Table 3-1 TMDL Numeric Targets

Indicator	Numeric Target	Waterbody
Total Algal Biomass	150 mg/m^2 chlorophyll *a* as seasonal average	Ventura River and tributaries
Macroalgal Cover (attached & unattached)	$\leq$ 30 percent (seasonal average)	Ventura River and tributaries
Phytoplankton Biomass	20 µg/L chlorophyll *a* as seasonal average	Estuary (shallow subtidal area)
Macroalgal Cover	$\leq$ 15 percent (seasonal average)	Estuary (intertidal and shallow subtidal areas)
Dissolved Oxygen	$\geq$ 7 mg/L daily minimum	River, Tributaries and Estuary
pH	6.5 – 8.5 (instantaneous value)	River, Tributaries and Estuary
Biomass and percent cover indicator targets apply during the growing season. The seasonal averaging period for algal biomass and percent cover is the growing season of May 1 to Septmeber 30th. River Indicators are averaged over a sampling reach as required by the SWAMP monitoring protocal Bioassessment SOP 02. Estuary macroalgal cover is measured using 3 transects and evaluating percent cover at 10 random points along each transect. Results are reported as a transect average. See methods used in the Bight '08 Estuarine Eutrophication Assessment (McLaughlin K et. al. Southern California Bight 2008 Regional Monitoring Program: Estuarine Eutrophication Assessment. Southern California Coastal Water Research Project. Costa Mesa, CA.		

The approach for setting the total algal biomass numeric target and establishing the TMDL is based on the California Nutrient Numeric Endpoints (NNE) framework (Tetra Tech 2006). The CA NNE, developed by USEPA Region 9 and the State and Regional Water Quality Control Boards, is a science-based approach to translate the narrative water quality objective for *Biostimulatory Substances* to numeric endpoints that can be applied in a TMDL or other regulatory program. The approach works to establish nutrient numeric endpoints based on an evaluation of site-specific risk to beneficial uses. The objective of the CA NNE is to control excess nutrient loads/concentrations to levels such that the risk or probability of impairing the beneficial uses is limited to an acceptably low level.

The NNE framework establishes a suite of biologically-based numeric thresholds (e.g. algal biomass) and links these thresholds to numeric nutrient endpoints (i.e. nutrient concentrations or loads) to address eutrophication. The linkage between the biological thresholds and numeric nutrient endpoints relies upon established load response relationships among nutrients, risk cofactors and biological response indicators and water quality models. The water quality models allow the derivation of site-specific nutrient allocations on the basis of site-specific conditions (i.e. most sensitive beneficial use, local characteristics of risk cofactors). This is presented in Sections 5 and 6, Linkage Analysis and Allocations.

The CA NNE is a scientifically sound approach because, except in extreme cases, increased nutrient concentrations do not directly impair beneficial uses. Rather, they cause indirect impacts by affecting biological response indicators like algal growth and low dissolved oxygen, which do directly impair beneficial uses (see conceptual models in Section 2). The indicators set as TMDL numeric targets provide a more direct measurement of beneficial use condition and whether beneficial uses are being fully supported in the waterbody. Additionally, the NNE framework provides multiple indicators (multiple TMDL numeric targets) in a weight of evidence approach, which provides a more robust means to assess beneficial uses.

For the total algal biomass indicator there is not definitive scientific consensus on the threshold that results in beneficial use impairment. This is because site-specific factors often play a significant role in determining the biological response to nutrient loading. To address this issue and provide for site-specific considerations the CA NNE includes a range of threshold values for biological indicators as presented in three Beneficial Use Risk Categories (BURC) (Tetra Tech, 2006). The categories are described below.

- BURC I: beneficial uses are attained and achieves narrative objective
- BURC II: may require an impairment assessment and site-specific nutrient endpoints
- BURC III: beneficial uses impaired and exceeds narrative objective

The BURC I/II boundary is the threshold below which there is general consensus that nutrients will not present a significant risk of beneficial use impairment. The BURC II/III boundary represents a value that is sufficiently high that there is consensus that the risk of beneficial use impairment by nutrients is likely above that threshold. Within BURC II, additional water body-specific cofactors should be considered as part of the analysis to determine an appropriate target.

Table 3-2 CA NNE Beneficial Use Risk Categories

Response Indicator	Risk – Category Boundary	Beneficial Use						
		COLD	WARM	REC 1	REC2	MUN	SPWN	MIGR
Benthic Algal Biomass in streams (mg chl-a/m2) -Maximum	I / II	100	150	C	C	100	100	B
	II / III	150	200	C	C	150	150	B
B – additional research is need to quantify linkage C – addressed by aquatic life criteria								

Regional Board staff used various lines of evidence to develop a numeric target for this TMDL. The California Nutrient Numeric Endpoints sets a benthic algal biomass target for the boundary between Beneficial Use Risk Category II and III for streams with a cold water aquatic habitat use (COLD) at 150 mg chlorophyll-a/m^2, interpreted as a maximum biomass in time averaged over a reach (i.e., it does not apply to single point measurements). The NNE boundary target is based on a review of both regional and international studies. The US EPA compiled results of research and expert recommendations and found general agreement that algal biomass greater than 150 mg/m^2 indicates nuisance conditions and water quality degradation in streams (US EPA, 2000b). This value is expected to protect the aquatic life and recreation beneficial uses.

The CA NNE provides for the evaluation of other lines of evidence to ensure the applicability of the boundary condition. Regional Board staff considered the 2008 diurnal oxygen impacts on reaches of the Ventura River where high amounts benthic algal biomass were observed and the well-established fact that the frequent low DO conditions present stressful conditions for resident (adult and juvenile) and migrating fish. An algal biomass target of 150 mg/m^2 is expected to minimize the risk of low DO events in the river and fully protect the aquatic life beneficial use (Welch and Jacoby, 2004).

The other biological indicators (macroalgal cover and phytoplankton biomass) are established as additional measures to track the symptoms of eutrophication and water quality improvements. These targets are based on the review of available data and scientific literature. The numeric target for attached and unattached macroalgal percent cover in the river is $\leq$ 30 percent. This value is based on recommendations from Biggs (2000); the guidelines presented in this document were developed to help protect streams from excessive nutrient loading.

The estuary phytoplankton biomass target of 20 µg/L is based on the Assessment of Estuarine Trophic Status (ASSETS), developed by the National Oceanic Atmospheric Administration (NOAA) National Estuarine Eutrophication Assessment (NEAA) (Bricker, 2003). The eutrophication indicators in the ASSETS framework were set to ensure accurate characterization of water quality conditions and the response ranges were selected to categorize and rank estuaries based on water quality ranges. Chlorophyll *a* is used a primary indicator for eutrophic condition. The values within the condition ranges were developed from data across the US and discussions with regional experts. The target of 20 µg/L is positioned on the high end of the medium water quality range.

For the macroalgal percent cover numeric target in the estuary, staff relied upon the classification framework presented in Scanlan (2007). The percent cover boundaries were set based on information from the UK Department of the Environment, Transport and the Regions 2001 expert workshop. The Scanlan study was not specific to estuaries in Mediterranean climates; however, a study conducted in coastal lagoons in Italy (Bona, 2006) corroborates the thresholds in Scanlan (2007) and demonstrates that these thresholds are reasonable for Mediterranean climates. The numeric target for percent cover algal biomass is set at $\leq$ 15 percent; this target equates to good water quality at moderate amounts of biomass. Both of these estuarine water quality assessment frameworks

(ASSETS and Scanlan) were also used by the Southern California Bight 2008 Regional Monitoring Program coordinated by the Southern California Coastal Water Research Project (SCCWRP) to evaluate estuarine eutrophication.

The numeric target for dissolved oxygen of 7 mg/L is set equal to the Basin Plan objective for all waters in the Ventura River Watershed designated COLD and SPWN. This target is also applied to the estuary, which is designated SPWN and MIGR because this watershed supports a Southern California steelhead trout cold water fishery.

Other Regional Boards in California have adopted algae and nutrient TMDLs for streams and estuaries which relied upon narrative water quality objectives and scientific literature and/or the CA NNE to translate the objective into TMDL numeric targets and allocations. Table 3-3 lists Regions and TMDLs in which this was done and the response indicator targets.

Table 3-3 Stream Nutrient TMDLs in Other Regions Where the Biostimulatory Substances Narrative Water Quality Objective were Applied

Region	TMDL		Indicator		
			Algal Biomass (mg/m^2)	Percent Cover	DO (mg/L)
1	Klamath River (2010)		150 (growing season average)	none	Reach specific monthly minimum 85 % saturation (winter) 90 % saturation (summer)
3	Chorro Creek (2006)		150	algal cover ≤ 40%	≥ 7 (daily minimum)
4	Malibu Creek (2003)	Creek	150	algal cover ≤ 30% for floating algae and ≤ 60% for bottom algae	≥ 7 (daily average)
		Lagoon	150	algal cover ≤ 30% for floating algae and ≤ 60% for bottom algae	≥ 7 (daily average)

4. SOURCE ASSESSMENT

This section identifies the potential sources of nutrients in the Ventura River watershed. In the context of TMDLs, pollutant sources are classified as either point sources or nonpoint sources. Nonpoint sources originate from land runoff, precipitation, atmospheric deposition, drainage, seepage or hydrologic modification. The term "nonpoint source" is defined to mean any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act. A point source as defined in the Clean Water Act means any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. Point sources as defined in the Clean Water Act include discharges from wastewater treatment plants and industrial and municipal storm drain outfalls, but do not include agricultural storm water discharges and return flows from irrigated agriculture.

The data review in this section focuses on identifying potential sources and providing nutrient loading estimates using available methods and data. The major categories of nutrient sources in the Ventura River watershed are:

Point Sources

- Stormwater and dry weather runoff from storm drains
- Ojai Valley WWTP discharge

Nonpoint Sources

- Runoff from horse and cattle facilities
- Runoff from agricultural areas
- Runoff from undeveloped natural areas
- Onsite wastewater treatment systems (i.e., septic tanks)
- Groundwater discharge
- Atmospheric deposition

For the purposes of the source assessment, the Ventura River watershed was divided into seven subwatersheds based on a GIS layer from VCWPD (Figure 4-1). These subwatersheds are the Upper Watershed, Ventura River Reach 4, Ventura River Reach 3, the Lower Watershed, San Antonio Creek, Cañada Larga, and Other (Coyote Creek above Casitas Dam).

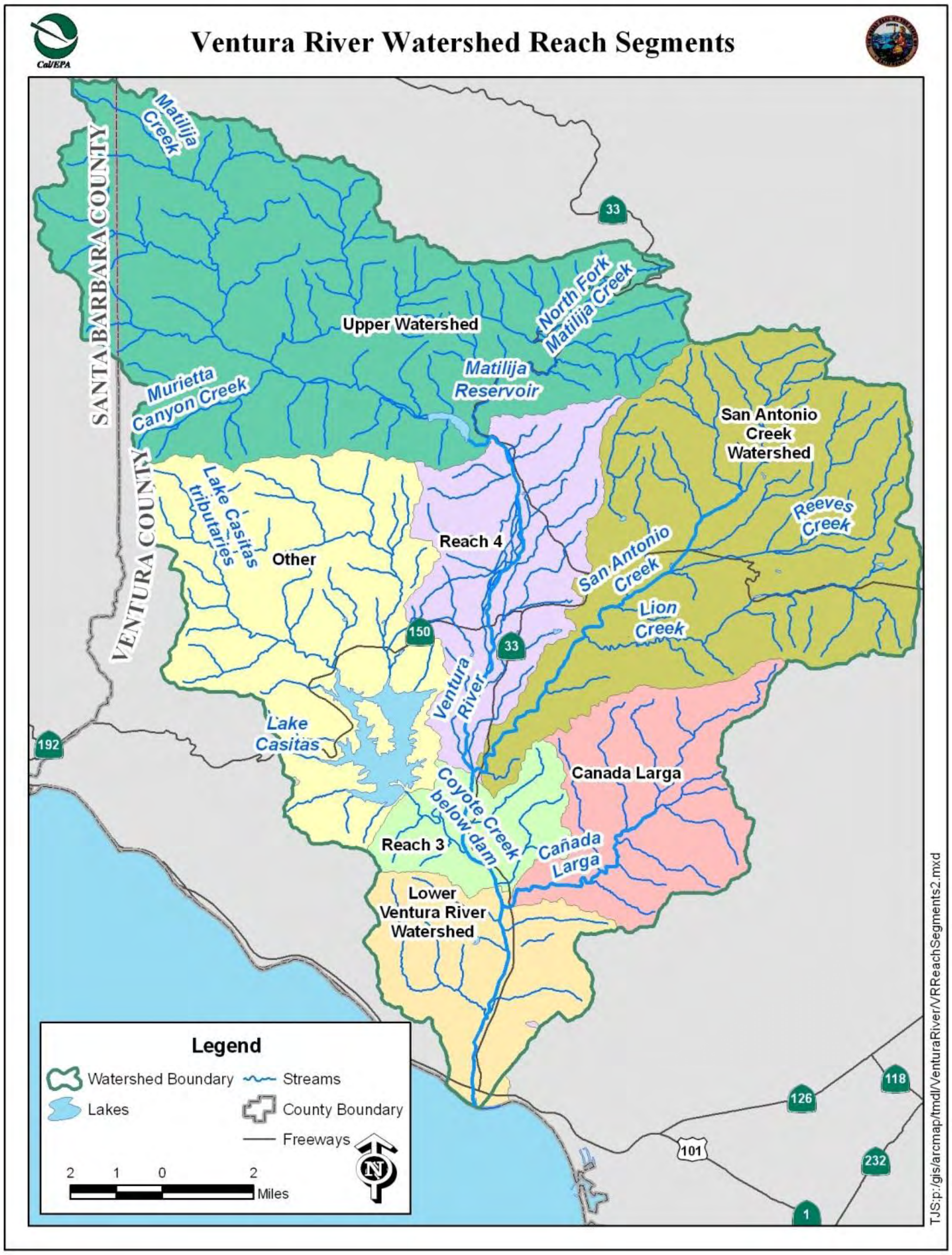

Figure 4-1 Ventura River Subwatershed

Most water in Lake Casitas goes to consumptive uses or evaporation and is rarely released below the dam (Tetra Tech, 2012). Therefore, the subwatershed draining to Lake Casitas is not considered a potential source of nutrients to the Ventura River for the purposes of this source assessment. Land that drains to Coyote Creek downstream of the dam is considered a source and is included in this source assessment as part of the Reach 3 subwatershed.

Land use data (Table 4-1) were obtained from Southern California Association of Governments (SCAG, 2005). The 2005 dataset was used because the 2008 SCAG dataset is based on parcels and can leave out roads, which are considered in this source assessment. In addition, it should be noted that the total area for the 2005 SCAG land use data does not match the total area of the watershed based on the watershed delineation in the GIS maps provided by VCWPD. However, the discrepancy in area is due to differences in the area of open space, which has a negligible effect on the source assessment. The land uses in Table 4-1 were aggregated into 17 categories corresponding to high density residential, low density residential, commercial, industrial, public facilities, education, transportation, mixed urban, open, water, recreation, cropland/improved pasture, orchards/vineyards, nurseries, dairy/intensive livestock, other agriculture, and horse ranches land uses. The acreages of various land uses were further grouped based on similar nutrient loading patterns for the purposes of this source assessment.

Table 4-1 Drainage Areas (acres) for Various Land Uses in the Ventura River Watershed

Land Use	Upper Water-shed	Reach 4	Reach 3	Lower Water-shed	San Antonio Creek	Cañada Larga	Coyote Creek	Total for Water-shed
High Density Residential	0	1256	28.8	611	680	33.2	0	2610
Low Density Residential	110	1548	154	20.9	2160	33.3	24.4	4051
Commercial	0	83	0	207	153	1.69	0	445
Industrial	12.6	6.53	25.3	2766	163	5.08	0	2978
Public Facilities	0	97.1	275	53.6	80.7	127	112	746
Education	0	99.3	0.05	52.9	227	0.04	0	379
Transportation	0	7.58	44.3	185	6.38	8.40	0	251
Mixed Urban	0	0	0	6.30	7.62	0	0	13.92
Open	40,838	8990	4865	5950	24,829	11,721	21,827	119,018
Water	30.1	10.99	0	6.56	25.52	0	2596	2669
Recreation	34.4	45.0	28.7	84.1	408	0	134	735
Cropland/ Improved Pasture	0	487	171	133	695	335	0	1821
Orchards/ Vineyards	3.41	1027	101	214	3009	21.9	25.5	4401
Nurseries	0	0	0	4.33	12.3	0	0	16.7
Dairy/Intensive Livestock	0	3.93	0	0	0	0	0	3.93
Other Agriculture	4.93	19.7	5.98	12.7	82.0	7.65	9.21	142
Horse Ranches	9.41	107	9.12	0	207	18.8	5.53	357
Total for all land uses	41,043	13,787	5709	10,307	32,745	12,312	24,734	140,638

4.1 Point Sources

The NPDES permits for stormwater and dry weather urban runoff discharges in the Ventura River watershed are the Ventura County municipal separate storm sewer system (MS4) permit (R4-2010-0108), the statewide California Department of Transportation (Caltrans) MS4 permit (99-06-DWQ), the statewide general industrial stormwater permit (97-03-DWQ), and the statewide general construction stormwater permit (2009-0009-DWQ).

The NPDES permits for wastewater and industrial discharges in the Ventura River watershed are for the Ojai Valley WWTP (R4-2008-0039) and four general NPDES permits for Foster Park Well Field (R4-2003-0108), Development and Startup Project Well #2 Aquifer Testing (R4-2003-0108), San Antonio Filter Plant (R4-2009-0047), and Golden State Water Company Ojai-Mutual Plant (R4-2003-0108) (Table 4-2).

Table 4-2 Summary of NPDES Permits in the Ventura River Watershed

Type of NPDES Permit	Total Permits
Ventura County MS4	1
Caltrans MS4	1
General Industrial Stormwater	28
General Construction Stormwater	14
Ojai Valley WWTP (Major)	1
General NPDES Permits	4
Total	50

This source assessment quantifies the point source loadings from stormwater and dry weather urban runoff sources and the Ojai Valley WWTP. The loadings from the general NPDES permits are not quantified in this source assessment. General Permit No. R4-2003-0108 is for discharges of groundwater from potable water supply wells to surface waters, including groundwater generated during well purging for data collection purposes, extracted from major well-rehabilitation and redevelopment activities, and generated from well drilling, construction, and development. General Permit No. R4-2009-0047 is issued to the San Antonio Filter Plant for the discharge of filter backwash water, redevelopment and start-up wastewater to San Antonio Creek. The discharges from the general NPDES permits are intermittent and considered negligible for the purposes of this source assessment.

4.1.1 Nutrient Loading from Stormwater and Dry Weather Urban Runoff Sources

Runoff from residential, industrial, commercial, and transportation areas is a significant source of nutrients to the Ventura River. The potential sources of nutrients from urban areas include fertilizer used for lawns and landscaping; organic debris from gardens, landscaping, and parks; trash such as food wastes; and domestic waste. Potential sources of nutrients from highways and transportation land uses include fallen leaves and other vegetation, vehicle exhaust, and atmospheric deposition. Nutrients build up, particularly on impervious surfaces, and are discharged into the receiving waters through storm drains when it rains or by dry weather runoff.

4.1.1.1 Wet-weather loading from Stormwater Sources

A Simple Method developed by Schueler (1987) was applied to estimate nutrient loads from urban stormwater runoff on annual basis to the Ventura River and its tributaries. This method was based on a relationship between rainfall and stormwater runoff volume with an associated nutrient concentration.

Load (L) = P×Pj×R×C×A×0.226 **Equation (1)**

Where:
L: Annual wet-weather pollutant load (lb/year)
P: Annual rainfall depth (inches/year)
Pj: Factor that corrects P for storms that produce no runoff, use Pj = 0.9
R: Runoff coefficient for land use type (unitless)
C: Pollutant concentration in runoff (mg/L)
A: Drainage area (acres)
0.226 = unit conversion factor (L-lb/acre-inch-mg)

The annual rainfall data (Table 4-3) over a 20-water year period from 1987 through 2007 was obtained from "Data Summary Report – Ventura River Watershed Hydrology Model" prepared by Tetra Tech (2008). The average rainfall value for a rain gauge in each subwatershed was assigned to that subwatershed and used to estimate stormwater runoff volumes.

Table 4-3 Summary of annual rainfall data in the Ventura River Watershed from 1987 through 2007 (Tetra Tech, 2008)

Subwatershed	Rain Gauge Station	Average Annual Rainfall (inches/year)
Upper Watershed	Matilija Canyon (D207)	36.0
Reach 4	Meiners Oaks – County Fire Station	23.9
Reach 3	Ventura – Kingston Reservoir	20.7
Lower Watershed	Ventura – Downtown (Courthouse)	16.9
San Antonio Creek	Ojai – County Fire Station	22.3
Cañada Larga	Oak View - County Fire Station	22.9

In order to calculate nutrient loading from stormwater runoff, the following land use categories, based on Table 4-1, were assumed:

- Residential = High Density Residential + Low Density Residential
- Other Urban = Public Facilities + Education + Mixed Urban
- Commercial = Commercial
- Industrial = Industrial
- Transportation = Transportation

Runoff coefficients for several land uses (Table 4-4) were based on values reported by Ackerman and Schiff (2003). Staff compared the runoff coefficients from Ackerman and Schiff with runoff coefficients calculated by Larry Walker and Associates using the 2006 VCWPD Hydrology Manual (LWA, 2011). The runoff coefficients calculated by LWA were derived assuming a certain percent impervious land cover for each land use type. The runoff coefficient is also a function of soil type and rainfall intensity, but using land use and percent imperviousness to provide a rough estimate of runoff coefficients is appropriate. The runoff coefficients reported by Ackerman and Schiff and those calculated by LWA are very similar and make little difference in the calculation of loadings. This source assessment uses the Ackerman and Schiff runoff coefficients for residential, commercial, industrial, other urban, and transportation land uses. The residential runoff coefficient was used to calculate loading from both high density and low density residential land uses. A runoff coefficient of 0.9 was applied to the transportation land use in the Ventura River watershed because of the high percentage of impervious surfaces associated with this land use.

Table 4-4 Runoff coefficients for various land uses

Land Use	Runoff Coefficient
Residential	0.39
Other Urban	0.41
Commercial	0.61
Industrial	0.64
Transportation	0.9

The concentration of nutrients in stormwater runoff (Table 4-5) were obtained from stormwater event mean concentrations (EMCs) monitored by VCWPD from residential, commercial, and industrial land use sites throughout Ventura County (VCSQMD, 2001) and from outfall monitoring sites within the Ventura River watershed at Meiners Oaks and Ojai from 2010 and 2011 for the other urban land use category. EMCs represent the concentration of a pollutant contained in stormwater runoff over the length of a storm event. The EMCs of total nitrogen and total phosphorus measured from Caltrans statewide monitoring (Kayhanian et al., 2002) were applied to calculate nutrient loads from transportation.

Table 4-5 Nutrient EMCs for various land uses (VCSQMD, 2001; VCWPD, 2010 and 2011; and Kayhanian et al., 2002)

Land Use	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
Residential	4.57	0.54
Other Urban	3.13	0.70
Commercial	1.91	0.24
Industrial	3.78	0.5
Transportation	3.0	0.3

The calculated annual nutrient loads from stormwater runoff for each subwatershed are shown in Table 4-6. The total nitrogen load to Ventura River and its tributaries from stormwater runoff is estimated to be 90,320 lb/year. The total phosphorus load is estimated to be 11,616 lb/year.

Table 4-6 Wet-weather TN and TP loading (lb/year) from stormwater discharges

Subwatershed	TN Load (lb/year)	TP Load (lb/year)
Upper Watershed	1663	200
Reach 4	26,168	3224
Reach 3	3622	580
Lower Watershed	29,912	3887
San Antonio Creek	27,472	3470
Cañada Larga	1483	255
Total Load	90,320	11,616

4.1.1.2 Dry-weather loading from urban runoff

Dry-weather runoff from activities such as irrigation, sidewalk washing, and car washing can pick up nutrients and flow into storm drains, which then discharge to receiving waters. Nutrient loading from dry weather urban runoff was calculated with the equation:

$L = Q \times C \times A \times 6.24\times10^{-5}$ **Equation (2)**

Where:
L: Daily dry-weather pollutant load (lb/day)
Q: Flow rate ($foot^3$/acre/day)
C: Pollutant concentration (mg/L)
A: Area (acres)
6.24×10^{-5} = unit conversion factor (lb-L/$foot^3$-mg)

The dry-weather flow rate for urban runoff was obtained from the VCSQMP Meiners Oaks and Ojai outfall monitoring stations (VCSWQMP, 2010). The reported flow rate for both of these stations from an event in 2010 was 0.5 cfs. This flow was multiplied by the percent urban land use that drained to each site (61% at Meiners Oaks and 49% at Ojai) in order to exclude flow contribution from other land uses. Then, the flow was divided by the area that drained to each site and the average of the two area-weighted flows was calculated. The resulting average area-weighted urban flow rate is 26.98 $foot^3$/acre/day.

The concentrations of total nitrogen and total phosphorus in dry weather urban runoff were obtained from the VCWPD Meiners Oaks and Ojai outfall monitoring stations for 2010 and 2011. The number of dry-weather days in the Ventura River Watershed was estimated to be 331 days based on data collected from Ventura River County Water District Gage 020 from 1987 to 2007. Multiplying the number of dry-weather days by the calculated daily nutrient load results in estimated annual dry-weather loads of 19,180 lb/year of TN and 243 lb/year of TP. See Table 4-7.

Table 4-7 Dry-weather TN and TP loading (lb/year) from dry-weather urban runoff

Subwatershed	TN Load (lb/year)	TP Load (lb/year)
Upper Watershed	205	1.91
Reach 4	5172	50.2
Reach 3	929	19.9
Lower Watershed	6712	109
San Antonio Creek	5805	55.8
Cañada Larga	357	5.45
Total Load	19,180	243

4.1.2 Nutrient Loading from Ojai Valley WWTP Discharge

The Ojai Valley WWTP has capacity of 3.0 MGD of tertiary-treated wastewater. The Ojai Valley Sanitary District serves 5,600 acres of watershed and the treatment plant provides wastewater collection services for an estimated population of 23,000 people in the city of

Ojai and in the communities of Meiners Oaks, Mira Monte, Oak View, Casitas Springs, and Foster Park.

Based on data collected from 2000 through 2012, Ojai Valley WWTP discharged tertiary-treated wastewater through an outfall at an average rate of 2.1 MGD into Ventura River. The discharge outfall is located approximately 3,000 feet upstream of the confluence of the Ventura River with Cañada Larga. The effluent concentrations of total nitrogen ranged from 2.6 mg/L to 21.1 mg/L, with an average of 5.86 mg/L. Nitrate-N was the dominant nitrogen compound, with concentrations ranging from 1.6 mg/L to 14.1 mg/L, and an average of 4.71 mg/L. Nitrite-N was generally below the detection limit of 0.1 mg/L. Ammonia-N was generally below the detection limit of 0.2 mg/L. Organic-N concentrations ranged from 0.2 mg/L to 12.7 mg/L, with an average of 1.1 mg/L. The total phosphorus concentration ranged from 0.062 mg/L to 5.7 mg/L, with an average of 1.38 mg/L. Phosphate-P was the dominant phosphorus compound, with concentrations ranging from 0.07 mg/L to 3.8 mg/L, and an average of 1.2 mg/L. (OVSD, 2000-2012).

The nutrient loading to Ventura River from Ojai Valley WWTP was estimated by multiplying the average effluent flow with average total nutrient concentrations (Table 4-8). The average annual loads of TN and TP were 37,475 lb/yr and 8855 lb/yr, respectively.

Table 4-8 TN and TP loading from Ojai Valley WWTP (OVSD, 2000-2012)

	Average Effluent Flow (MGD)	Average TN (mg/L)	Average TP (mg/L)	Average TN Load (lb/day)	Average TP Load (lb/day)	Average TN Load (lb/year)	Average TP Load (lb/year)
Ojai Valley WWTP	2.1	5.86	1.38	103	24.3	37,475	8855

4.2 Nonpoint Sources

Nonpoint sources in the Ventura River watershed include inputs from agricultural lands, horses and livestock, onsite wastewater treatment systems, groundwater, undeveloped open space, wildlife, and atmospheric deposition. This section provides an overview of each source and presents data to characterize each source.

4.2.1 Nutrient Loading from Agricultural Lands

Phosphorus and nitrogen that are applied to agricultural lands as fertilizer can be washed into receiving waters due to irrigation or stormwater runoff. In addition, nutrients applied to the land can migrate to groundwater, which in areas of groundwater upwelling, can also be a source of nutrients to surface water. As of April 2011, there were 143 agricultural land owners representing 4066 irrigated acres in the Ventura River watershed enrolled in the Conditional Waiver for Discharges from Irrigated Lands (Agriculture Waiver) through the Ventura County Agricultural Irrigated Lands Group (VCAILG). According to the 2010 annual monitoring report, avocado and citrus orchards are the predominate crops in the Ventura River watershed (VCAILG, 2011).

4.2.1.1 Wet-Weather Nutrient Loading from Agriculture

Equation 1 and the annual rainfall data in Table 4-3 were used to estimate the wet-weather nutrient loading from agricultural lands. A runoff coefficient of 0.1 (Ackerman and Schiff, 2003) was applied to agricultural land uses (including cropland/improved pasture, orchards/vineyards, nurseries, and other agriculture) in the Ventura River watershed.

Nutrient concentrations in wet-weather agricultural runoff were obtained from 2007, 2008, 2009, and 2010 VCAILG annual monitoring reports (Table 4-9). Data for orchards were obtained from the two VCAILG monitoring sites in the Ventura River. Because there are no VCAILAG monitoring sites in the Ventura River watershed that collect runoff from cropland/improved pasture, nurseries, and other agriculture, data from these land uses were obtained from VCAILG's Central Ditch monitoring site in the nearby Santa Clara River Estuary subwatershed. Since total nitrogen and total phosphorus concentrations are not reported, the concentration of nitrate is assumed as the concentration for total nitrogen, and the concentration of phosphate is assumed as the concentration for total phosphorus. This is a reasonable assumption because these two elements are generally applied to agriculture facilities in the form of synthetic fertilizer which are dominated by the biologically available form of the nutrient.

Table 4-9 Concentrations of nutrients in wet-weather runoff for various agricultural land uses (VCAILG, 2008, 2009, 2010, 2011)

Land Use	Nitrate (mg/L)	Phosphate (mg/L)
Cropland/Improved Pasture	19.83	1.40
Orchards	1.84	0.16
Nurseries	19.83	1.40
Other Agriculture	19.83	1.40

From Equation (1), the annual wet-weather nitrogen load from agricultural lands to the Ventura River and its tributaries is estimated to be 21,390 lb/year (Table 4-10) and the phosphorus load is estimated to be 1572 lb/year (Table 4-11).

Table 4-10 Annual wet-weather nitrogen loading (lb/year) from agricultural land uses

Subwatershed	Cropland/Improved Pasture	Orchard	Nursery	Other Agriculture	Total Load
Upper Watershed	0	5	0	72	76
Reach 4	4691	918	0	190	5799
Reach 3	1432	78	0	50	1560
Lower Watershed	910	135	30	87	1161
San Antonio Creek	6251	2511	111	738	9611
Cañada Larga	3093	19	0	71	3182
Total Load	16,376	3666	140	1207	21,390

Table 4-11 Annual wet-weather phosphorus loading (lb/year) from agricultural land uses

Subwatershed	Cropland/Improved Pasture	Orchard	Nursery	Other Agriculture	Total Load
Upper Watershed	0	0	0	5	5
Reach 4	332	80	0	13	425
Reach 3	101	7	0	4	112
Lower Watershed	64	12	2	6	84
San Antonio Creek	442	218	8	52	720
Cañada Larga	219	2	0	5	225
Total Load	1158	319	10	85	1572

4.2.1.2 Dry-Weather Nutrient Loading from Agriculture

Equation 2 was used to calculate dry-weather nutrient loading from open space. A dry-weather runoff rate was obtained from the Ventura County Farm Bureau based on water demand by crop type and consensus values for percent runoff from water applied (Farm Bureau, 2010). The resulting runoff rate of 16.85 $feet^3$/acre/day was used for the calculation of nutrient loads from cropland/improved pasture, orchards/vineyards, nurseries, and other agriculture. The runoff rate from orchards is zero because no dry weather runoff has been measured at the two VCAILG monitoring sites, which drain orchards, in the Ventura River watershed.

Nutrient concentrations in dry-weather agricultural runoff were obtained from 2007, 2008, 2009, and 2010 VCAILG annual monitoring reports. Concentrations for orchards are zero based on the two VCAILG monitoring sites in the Ventura River. Data for cropland/

improved pasture, nurseries, and other agriculture were obtained from VCAILG's Central Ditch monitoring site. Central Ditch drains a more intensely farmed drainage area than the Ventura River watershed and receives discharges from tile drains, which concentrate nutrient concentrations. The average concentrations of nitrate and phosphate in dry-weather runoff from these crop types are 15.4 mg/L and 0.06 mg/L, respectively. Since total nitrogen and total phosphorus concentrations are not reported, the concentration of nitrate is assumed as the concentration for total nitrogen, and the concentration of phosphate is assumed as the concentration for total phosphorus.

The estimated dry-weather nutrient loads from agricultural lands are summarized in Table 4-12 and 4-13. The number of dry-weather days in the Ventura River Watershed was estimated to be 331 days. The dry-weather loading of TN and TP to the Ventura River and its tributaries is 10,389 lb/year and 41.2 lb/year, respectively.

Table 4-12 Dry-weather nitrogen loading (lb/year) from agriculture land uses

Subwatershed	Cropland/Improved Pasture	Orchard	Nursery	Other Agriculture	Total Load
Upper Watershed	0.0	0	0	26.0	0.0
Reach 4	2565	0	0	104	2565
Reach 3	904	0	0	31.5	904
Lower Watershed	703	0	22.8	67.1	703
San Antonio Creek	3663	0	64.9	432	3663
Cañada Larga	1765	0	0	40.3	1765
Total Load	9600	0.0	88	701	10,389

Table 4-13 Dry-weather phosphorus loading (lb/year) from agriculture land uses

Subwatershed	Cropland/Improved Pasture	Orchard	Nursery	Other Agriculture	Total Load
Upper Watershed	0	0	0	0.1	0
Reach 4	10.2	0	0	0.4	10.2
Reach 3	3.6	0	0	0.1	3.6
Lower Watershed	2.8	0	0.1	0.3	2.8
San Antonio Creek	14.5	0	0.3	1.7	14.5
Cañada Larga	7.0	0	0	0.2	7.0
Total Load	38.0	0.0	0.3	2.8	41.2

4.2.2 Nutrient Loading from Horses/Livestock

Manure produced by horses, cattle, and other livestock in the Ventura River watershed is a significant source of nutrients. Manure can be washed into receiving waters during wet weather and can also migrate to groundwater, which can thence be discharged to surface water. Manure can also be discharged to receiving waters in dry weather due to poor manure management or grazing activities that disturb stream banks and riparian areas and cause erosion, which increases the discharge of sediment, animal waste, and nutrients to surface waters.

According to SCAG data, there are about 357 acres of horse ranches in the Ventura River watershed (Table 4-1). In addition, there are low-density residential properties within the watershed with horses on the properties. The low-density residential acreage is not accounted for in estimating the horse ranch acreage in the watershed. The actual area of horse-impacted land uses may be greater than 357 acres.

According to SCAG data, there are 3.93 acres of dairy/intensive livestock land use in the watershed (Table 4-1). Based on 2007 US Department of Agriculture (USDA) Census data, it was determined that there are approximately 1940 cattle in the Ventura River watershed (USDA, 2009). According to the Ventura County Resource Conservation District, each cow needs approximately 30 acres of land and most cattle operations in the Ventura River watershed are on leased land (Melvin, 2012). Thus, the SCAG area does not represent all of the cattle grazing activities in the watershed. Therefore, this source assessment considered the California Department of Conservation's Farmland Mapping Program to determine the area of cattle grazing in the Ventura River watershed. Spatial data of the area in Ventura County suitable for grazing was clipped to the Ventura River watershed using GIS. The grazing data were then overlain with SCAG data to exclude areas that were obviously not used for grazing, such as oil and gas exploration and areas slated for development. The resulting area suitable for grazing in the Ventura River watershed (excluding Coyote Creek) is about 34,000 acres and generally overlaps with SCAG open space land use classifications.

4.2.2.1 Wet-Weather Nutrient Loading from Horses/Livestock

Equation 1 and the annual rainfall data in Table 4-3 were used to estimate the wet-weather nutrient loading from horses/livestock. A runoff coefficient of 0.50 was assumed for dairy/intensive livestock and horse ranch land uses. A runoff coefficient of 0.06 was applied for grazing areas because, for the purposes of this source assessment, it was assumed that all grazing activities occurred on open space land uses.

Nutrient concentrations in wet-weather runoff from dairy/intensive livestock and horse ranch land uses were obtained from a 2007 study on wet-weather runoff from horse paddocks (Airaksinen, 2007). Runoff was collected from several areas of two paddocks during three different sampling periods. The lowest numbers reported for the spring sampling period were selected for this source assessment: 18.3 mg/L total nitrogen and 3.4 mg/L total phosphorus.

Nutrient concentrations in wet-weather runoff from cattle grazing were obtained from the USDA Measured Annual Nutrient loads from Agricultural Environments (MANAGE) database, which includes measured nitrogen and phosphorus load data published in

scientific peer-reviewed studies. The mean concentrations for rangeland/pasture from the MANAGE database are 4.85 mg/L total nitrogen and 0.69 mg/L total phosphorus.
From Equation 1, the wet-weather total nitrogen loads to Ventura River and its tributaries were estimated to be 175 lb/year from dairy/intensive livestock, 15,141 lb/year from horse ranches, and 39,009 lb/year from cattle grazing (Table 4-14). The total phosphorus loads were estimated to be 32 lb/year from dairy/intensive livestock, 2813 lb/year from horse ranches, and 5557 lb/year from cattle grazing (Table 4-15).

Table 4-14 Wet-weather nitrogen loading (lb/year) from horses/livestock

Subwatershed	Dairy/Intensive Livestock	Horse Ranches	Grazing
Upper Watershed	0	630	0
Reach 4	175	4759	2591
Reach 3	0	351	5783
Lower Watershed	0	0	4877
San Antonio Creek	0	8598	11,100
Cañada Larga	0	802	14,658
Total Load	175	15,141	39,009

Table 4-15 Wet-weather phosphorus loading (lb/year) from horses/livestock

Subwatershed	Dairy/Intensive Livestock	Horse Ranches	Grazing
Upper Watershed	0	117	0
Reach 4	32	884	369
Reach 3	0	65	824
Lower Watershed	0	0	695
San Antonio Creek	0	1597	1581
Cañada Larga	0	149	2088
Total Load	32	2813	5557

4.2.2.2 Dry-Weather Nutrient Load from Horses/Livestock

Dry-weather nutrient loading from horses was estimated using the number of animals, manure production rates, and the amount of nutrients transported to surface waters. The dry-weather nutrient loading from cattle was not quantified. Instead, this source assessment contains a qualitative discussion of cattle as a source of dry-weather nutrient loading.

<u>Loading from Horse Ranches</u>

In 2009, Hawks & Associates conducted a preliminary survey of horses in the main Ojai Valley, which includes most of the Reach 4 and a large portion of the San Antonio Creek subwatersheds. The estimated total number of horses in the Ojai Valley ranged from 2000 to 3000. For the purposes of this source assessment, it was assumed that there were 2000 horses in the entire Ventura River watershed and the horses were allocated among each subwatershed based on area.

The manure production rates and associated nutrients were based on the American Society of Agricultural Engineers (ASAE) Manure Production and Characteristics Standard (ASAE, 2003), as summarized in Table 4-16. The unit waste production rate was multiplied by the number of horses to determine the nutrient loading from horses. It was then assumed that 10 percent of the manure is loaded to waterbodies via washwater, dumping, or when animals go near stream banks. TKN is assumed as the concentration for TN for the calculation of nitrogen load.

Table 4-16 Daily nutrient waste production rates for horses (ASAE, 2003)

Animal Type	Weight (lb)	TKN (lb/day)	Total P (lb/day)	PO4-P (lb/day)
Horse	1000	0.3	0.07	0.019

The number of dry-weather days in the Ventura River Watershed was estimated to be 331 days. Multiplying the dry-weather TN and TP loading per horse by the number of horses in the watershed and apportioning this loading throughout the subwatersheds, results in the dry-weather nutrient loading presented in Table 4-17.

Table 4-17 Dry-weather nutrient loading from horses in the Ventura River Watershed

Subwatershed	TN (lb/year)	TP (lb/year)
Upper Watershed	0	0
Reach 4	1187	281
Reach 3	3058	724
Lower Watershed	3159	748
San Antonio Creek	5449	1290
Cañada Larga	7007	1658
Total Loads	19,860	4700

<u>Loading from Cattle</u>

While cattle grazing can have a significant impact on dry-weather nutrient loading, the impacts are indirect and can be difficult to quantify. For example, when cattle are allowed to graze directly on streambanks, the bank structure can be destabilized, causing soil and associated nutrient loading into the stream. The loss of riparian vegetation also reduces shade and the buffering capacity of the stream. Finally, the loss of riparian vegetation and weakened streambanks decreases the depth and increases the width of the stream, which can increase its temperature. Such indirect effects impact the amount of nutrient loading to the stream and the stream's ecological response to the nutrient loading. The impacts will vary considerably depending on site-specific conditions such as vegetation cover, grazing density, proximity to the stream, and period of use (USEPA, 2003). Without site-specific data on ranching practices in the Ventura River watershed, dry-weather loading from cattle grazing cannot be quantified.

Dry-weather loading from intensive livestock/dairy land uses was not quantified either. The dry-weather impacts from intensive livestock/dairy land uses are similar to the impacts from both grazing activities and horse ranches. However, the number of cows associated with intensive livestock/dairy versus the number of cows associated with grazing is not known. From Table 4-1, the area of intensive livestock/dairy is negligible (4 acres) compared to the area estimated for grazing (34,000 acres) and the area of horse ranches (357 acres), so the relative contribution of dry-weather loading form intensive livestock/dairy is small and roughly accounted for in the dry-weather loading estimates for horses.

Regardless of the fact that there is no quantified source assessment for intensive livestock/dairy land uses and cattle grazing activities, this TMDL assigns both of these sources load allocations.

4.2.3 Nutrient Loading from Onsite Wastewater Treatment System

An Onsite Wastewater Treatment System (OWTS), or septic system, consists of a septic tank and a soil absorption field that allows effluent to infiltrate through soil. Septic systems can be significant sources of nutrients to subsurface and surface waters when they are not properly sited or functioning. Wastewater with high concentrations of nitrogen and phosphorus may seep into shallow groundwater and eventually enter surface waters. Nitrogen is particularly mobile in groundwater, while phosphorus has a tendency to be absorbed by the soils.

This source assessment relies on an estimate conducted by LWA of the total number of septic systems discharging within the Ventura River watershed (2,131). LWA created a list of parcels with structures having private or public restrooms where there are no sewer lines. The total number of septic systems was derived by subtracting the parcels where sewer services are available from all parcels. The map of sewered areas and parcels with possibly-existing septic systems in the Ventura River watershed is shown in Figure 4-2 (LWA, 2011). The resulting estimated number of 2131 is borne out by a review of septic system applications/permits to the Ventura County Environmental Health Division, which shows 1422 septic systems in the Ventura River watershed. This represents the number of septic systems permitted by Ventura County. The number of commercial and multifamily septic systems permitted by the Regional Board is approximately 22. There are potentially more unpermitted septics systems in the Ventura River Watershed. Thus, the number of 2131 estimated by LWA is a good approximation of the total number of septic systems in the watershed.

OWTS may fail due to improper siting, design, and/or maintenance. Inadequate treatment may also result from insufficient vertical separation to the groundwater, insufficient horizontal separation to a surface water, or surface discharge from a failed disposal field. Nutrient loss rates to surface water of 32% nitrogen and 10% phosphorus were obtained from a nutrient groundwater/surface water interaction study for the Malibu Lagoon (Lai, 2009) and were applied for the calculation of nutrient loads.

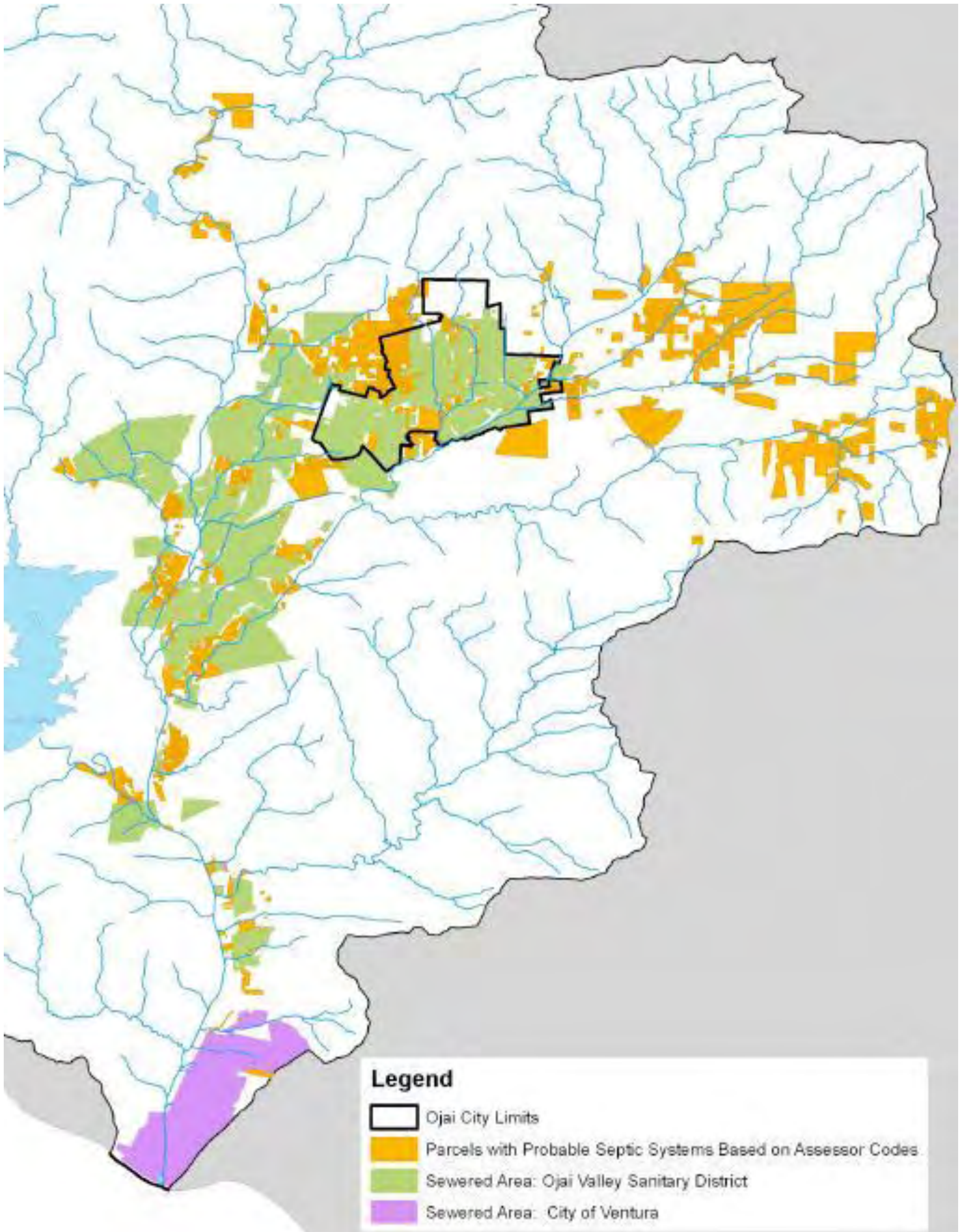

Figure 4-2 Potential OWTS in the Ventura River watershed (LWA, 2011)

The nutrient loads from septic systems were calculated assuming a daily average effluent flow rate of 200 gallons per household, and effluent nutrient concentrations of 36 mg/L nitrogen and 6 mg/L phosphorus (LWA, 2011). LWA estimated based the nitrogen and phosphorus concentrations on the average total nitrogen and phosphorus concentrations measured in Ojai Valley WWTP influent for the period of 1999-2008. The annual nutrient loading to the Ventura River watershed from OWTS is thus 14,955 lb-TN and 779 lb-TP.

4.2.4 Nutrient Loading from Open Space

Open spaces can contribute background nutrient loading due to decay of natural vegetation as well as nitrogen- and phosphorus-bearing rocks and soils. The nutrients are mobilized during wet-weather events or as groundwater discharge to surface waters.

4.2.4.1 Wet-weather loading from open space

Equation 1 and the annual rainfall data in Table 4-3 were used to calculate wet-weather nutrient loading from open space. A runoff coefficient of 0.06 was applied because of the largely pervious area that comprises natural undeveloped areas (Ackerman and Schiff, 2003). The pollutant concentrations in wet-weather runoff from open space were obtained from a SCCWRP study that measured total nitrogen and total phosphorus concentrations from 18 natural stream reaches across southern California (Yoon and Stein, 2008). The study collected total nitrogen and total phosphorus EMCs from two wet seasons between December 2004 and April 2006. The geometric means of all of the sampling events were 1.5 mg/L and 0.03 mg/L for total nitrogen and total phosphorus, respectively.

The open space area was adjusted by subtracting out the area that was used for the estimate of wet-weather loading from livestock grazing activities located in open space areas (Table 4-18).

Table 4-18 Adjusted open space areas

Subwatershed	Open Space (Acres)	Grazing Area (Acres)	New Open Space (Acres)
Upper Watershed	40,838	0	40,838
Reach 4 Watershed	8990	1833	7157
Reach 3 Watershed	4865	4722	143
San Antonio Creek	24,829	8414	16,414
Cañada Larga	11,721	10,820	901
Lower Watershed	5950	4878	1071

Using Equation 1, the wet-weather loading from open space is estimated to be 40,009 lb/year of total nitrogen and 750 lb/year of total phosphorus (Table 4-19).

Table 4-19 Wet-weather TN and TP loading (lb/year) from open space

Subwatershed	TN Load (lb/year)	TP Load (lb/year)
Upper Watershed	28,707	538
Reach 4	3340	62.6
Reach 3	57.8	1.1
Lower Watershed	354	6.6
San Antonio Creek	7148	134
Cañada Larga	403	7.6
Total Load	40,009	750

4.2.4.2 Dry-weather loading from open space

Equation 2 was used to calculate dry-weather nutrient loading from open space. Dry-weather flows from undeveloped areas are from interflow, rising groundwater, springs, and seeps. Dry-weather flows were obtained from USGS Gage 11116000 in North Fork Matilija from 1987-2007 as reported in the "Data Summary Report – Ventura River Watershed Hydrology Model" (Tetratech, 2008). The dry-weather flow was calculated as the median of reported monthly median flows for dry-weather months (April to October). The resulting flow (1.2 cfs) was then divided by the area that drains to USGS Gage 11116000 (9984 acres) to obtain an area-weighted open space dry weather flow of 10.38 cfs/acre/day.

The pollutant concentrations in dry-weather runoff from open space were obtained from a SCCWRP study that measured total nitrogen and total phosphorus concentrations from 22 natural stream reaches in dry weather across southern California (Stein and Yoon, 2007). The study collected nitrogen and phosphorus data from three dry seasons in spring 2005, fall 2005, and spring 2006. The geometric means of all of the sampling events were 0.33 mg/L and 0.05 mg/L for total nitrogen and total phosphorus, respectively. The number of dry-weather days in the Ventura River Watershed was estimated to be 331 days

From Equation 2, the annual dry-weather loads of TN and TP to Ventura River and its tributaries are estimated to be 6879 lb/year and 1042 lb/year, respectively (Table 4-20).

Table 4-20 Dry-weather TN and TP loading (lb/year) from open space

Subwatershed	TN Load (lb/year)	TP Load (lb/year)
Upper Watershed	2891	438
Reach 4	636	96.4
Reach 3	344	52.2
Lower Watershed	421	63.8
San Antonio Creek	1757	266
Cañada Larga	830	126
Total Load	6879	1042

4.2.5 Nutrient Loading from Groundwater Discharge

The Ojai Valley Basin, Upper Ojai Basin, Upper Ventura Basin, and Lower Ventura Basin are the major groundwater basins in the Ventura River watershed. The Ojai Basin is recharged where Thacher Creek, San Antonio Creek, and Reeves Creek enter the basin at alluvial fan heads (Tetratech, 2012). Groundwater from the Ojai Basin flows into the Upper Ventura River Basin and influences water quality there (VCWPD, 2010). Water from the mainstem of the Ventura River recharges the Upper and Lower Ventura River Basins (Tetratech, 2012). Groundwater in the Upper Ventura Basin moves south through the alluvium, following the surface flow, and enters the Lower Ventura River subbasin below Foster Park (CDWR, 2004a). In the Lower Ventura River Subbasin, groundwater follows the course of the river to the Pacific Ocean (CDWR, 2004b).

Natural sources of nitrate in groundwater are due to decay of natural vegetation and nitrogen bearing rocks. Other than natural sources, surface water recharge, septic systems, and fertilizers and manure that migrate to groundwater via infiltration, are also causes of elevated nitrate concentrations in groundwater. No information is available on phosphorus concentrations in groundwater in the watershed.

Groundwater in the shallow alluvium provides the base flows to the Ventura River and its tributaries and is a major source of water during the dry season. Therefore, dissolved nutrients in groundwater have more significant impact during dry-weather periods.

The estimated groundwater discharge to surface water for the Lower Ventura River subbasin is 1,254 acre-feet/year or 1.73 cfs (Daniel B. Stephens & Associates, Inc., 2010). The average nitrate-N concentration is about 1.23 mg/L as measured in surrounding wells (VCWPD, 2010). Therefore, the estimated nitrogen load to the Lower Ventura River subbasin is 4192 lb/year.

4.2.6 Nutrient Loading from Atmospheric Deposition

Atmospheric deposition is recognized as a potential source of nitrogen and phosphorus to coastal waters and watersheds in southern California. These pollutants are deposited by wet or dry deposition. Wet deposition refers to pollutants that are removed from the air by precipitation. Dry deposition occurs when pollutants settle out of the air and onto land or water surfaces. The two mechanisms of dry deposition are direct deposition (deposited directly onto a water surface) and indirect deposition (deposited onto surrounding land surfaces in the watershed and subsequently washed into surface waters). Direct atmospheric deposition is a very small proportion of the nutrient sources because the water surfaces of the Ventura River and its tributaries represent less than 1 % of the total watershed area. The much larger fraction of nutrient loading is by indirect deposition. The actual load attributed to indirect deposition is unknown because the fraction of deposited nitrogen and phosphorus that are consumed by terrestrial plants, transformed within the soils by bacteria, and abiotically degraded remains unquantified (Lu, et al., 2004). The contribution of nutrients by indirect deposition is accounted for in the wet-weather loading estimates for the various land uses described in the previous sections.

To calculate to the contribution of direct deposition during the dry-weather period, the length of the Ventura River, including its tributaries, is estimated to be 42 miles, and the average width of the river is approximately 20 feet. The surface area of the creek is thus approximately 0.16 square miles, or 41 hectares (ha). Because the deposition flux rate in the Ventura River watershed is not available, the mean dry deposition flux of total nitrogen (21.2 g/ha/day) in the Malibu Creek watershed is applied for calculation (Lu, et al., 2004). The resulting TN load is approximately 1.94 lb/day. The average dry-weather day in Ventura River watershed is 331 days. The annual nitrogen load from air deposition is thus approximately 534 lb/year. The general atmospheric deposition rate for total phosphorus is 1.64 g/ha/day (USEPA, 1994). The resulting TP load from air deposition is approximately 0.15 lb/day or 41 lb/year.

4.3 Summary of Source Assessment

A summary of the source assessment by sources/land use types is presented in Table 4-20. Based on available data and an estimation of nutrient loadings, stormwater and dry weather urban runoff via the MS4 contributes a large percentage of the nutrients to the Ventura River and its tributaries (21.3% in dry weather and 28.3% in wet weather). The Ojai Valley WWTP contributes a large portion of nutrient loading in dry-weather (37.6%) but a smaller portion in wet weather (1.7%). Horses/livestock and agricultural land uses contribute significant loading in both dry and wet weather. Open space loading is a significant source of nutrients in wet weather (19.1%) and a smaller source of nutrients in dry weather (7.6%). All sources of nutrients are assigned WLAs and LAs in the TMDL.

Table 4-21 Summary of TN loading for all sources/land uses in the Ventura River watershed

Source Type	TN (lb/year)	% total	% dry	% wet
Dry Weather				
Dry-weather Runoff from Urban Areas	19,180	6	21.3	n/a
Ojai Valley WWTP_dry days	33,984	11.7	37.6	n/a
Dry-weather Runoff from Agriculture	10,389	3.3	11.5	n/a
Dry-weather Runoff from Horse/Livestock	19,860	6.2	22.0	n/a
Dry-weather Runoff from Open Space	6879	2.2	7.6	n/a
Wet-weather				
Urban Wet-weather Runoff	90,320	28.3	n/a	43.1
Ojai Valley WWTP_wet days	3491	NA	n/a	1.7
Agriculture Wet-weather Runoff	21,390	6.7	n/a	10.2
Horse/Livestock Wet-weather Runoff	54,325	17.0	n/a	25.9
Open Space Wet-weather Runoff	40,009	12.5	n/a	19.1
Groundwater Discharge	4191	1.3		
Septic Systems	14955	4.7		
Atmospheric Deposition	641	0.2		
Total Load	319,614			

5. LINKAGE ANALYSIS

Information on sources of pollutants provides one part of the TMDL analysis. To determine the effects of sources on water quality, it is necessary to also determine the linkage between the nutrient loading, expected in-stream water nutrient concentrations, and allowable amounts of algal biomass. This will define the assimilative capacity of the receiving water under critical conditions. This section describes the approach used to determine the nutrient loading that can be assimilated by Ventura River, its tributaries and the estuary, while ensuring attainment of the numeric targets (presented in Section 3) and protection of beneficial uses. This section also describes the critical condition.

5.1 Critical Condition

The critical condition is the period in which the receiving waterbody is most sensitive to the impacts associated with the pollutants of concern. The critical condition for the Ventura River and its tributaries, and the Estuary are evaluated separately.

5.1.1 Critical condition for the Ventura River and tributaries

As described in Section 2, the exceedances of the dissolved oxygen and biostimulatory substances water quality objectives caused by increased nutrient loading and eutrophication are a dry-season problem (May 1 to September 30). The ecology of algae in rivers is, in part, dependent on temperature and flow. An analysis of flow conditions in the Ventura River watershed (Tetratech, 2012) shows that flows vary depending on rainfall conditions, with highest flows at the end of winter and early summer due to receding baseflows from winter rains, and lowest flows at the end of summer and early winter. Dry-weather flows are highest in the upper watershed, both above and below the Matilija Dam (gages 603A and 602), and decrease lower in the watershed but above the Ojai WWTP (gage 607 in Reach 4 and gage 608 in Reach 3) due to evapotranspiration, infiltration, and water withdrawal. Storm flows are more consistent throughout the watershed, but are lower in Reach 4 than in Reach 3 and the upper watershed (Figure 5-1).

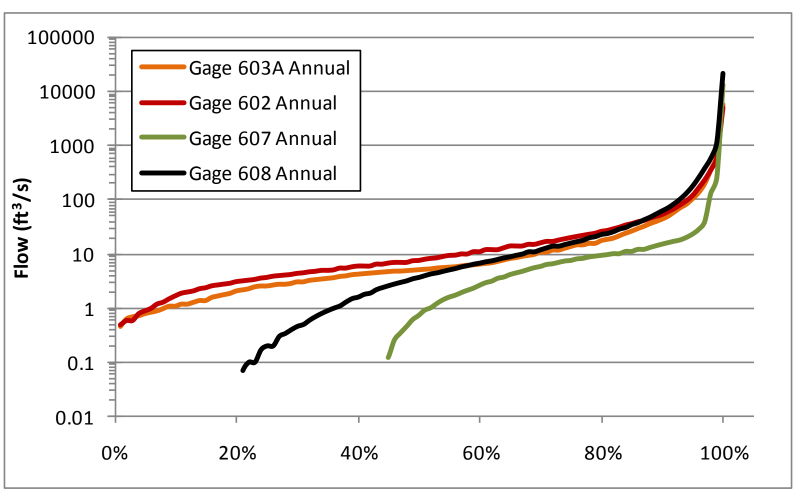

Figure 5-1 Distribution of Flows throughout the Ventura River (Tetratech, 2012)

Below gage 608, the Ojai WWTP is a significant source of water. The Ojai WWTP discharges to Reach 2 and regularly constitutes more than half the flow to the Estuary; 12 percent of the time it is 95 percent of the flow (Tetratech, 2012).

The critical condition in the Ventura River watershed occurs in dry season (May 1 to September 30) when flows are lowest and temperatures highest, creating favorable conditions for algae growth in the river.

Additionally, an analysis of nutrient uptake lengths (i.e. the average distance a nutrient molecule travels before being taken up by biota in the stream) in Ventura River demonstrated uptake lengths much longer than typically observed in small rivers. The summer uptake lengths for TN and TP were 3.6 km and 3.7 km, respectively. Typically, in small unimpaired streams, nutrient uptake lengths are on the order of meters not kilometers (Tetratech, 2012). The long nutrient uptake lengths indicate an ample supply of nutrients in the ecosystem – a nutrient molecule can travel a significant distance before it is taken up by biota in the system. Typically, when nutrients are in limited supply they are very quickly taken up and tightly recycled in the system resulting in very short uptake lengths. The long nutrient uptake length indicates that nutrients loaded in the upper watershed and tributaries have an impact on nutrients concentrations and biological response in the lower reaches; therefore, allocations are assigned to all sources throughout the watershed to attain numeric targets in all reaches and tributaries.

5.1.2 Critical Condition for the Ventura Estuary

The critical condition in the Estuary occurs during the dry season (May to October), when freshwater inputs dominate, temperatures are higher, and there is a higher probability of a berm forming at the Estuary mouth. A closed berm reduces flushing and increases the residence time of nutrients in the Estuary, which, as discussed in Section 2, are important co-factors affecting the Estuary's ecological response to nutrient loading.

An analysis was conducted on the hydrology of the Estuary (Tetratech, 2012). Flows to the Estuary were calculated by summing flows from Gage 608, Cañada Larga, and the Ojai Valley WWTP. It was determined that the majority of flows to the Estuary occur during winter months, except during drought years (e.g., 2006), due to the significance of wet-weather flows. However, it was also determined that the Estuary is directly connected to the ocean 81% of the time based on visual observations conducted by Ojai Valley Sanitation District between January 1999 and December 2003. When the Estuary was closed, it occurred during the months of July to October, during the dry season.

A predictive conceptual model was developed (Tetratech, 2012) based on the observation that the Estuary was usually closed when flows were less than 10 cfs and open when flows were greater than 10 cfs. It was assumed that a peak flow of 50 cfs was needed to open the Estuary, a flow of 10 cfs was needed to maintain a connection to the ocean, and a flow of less than 10 cfs for 30 days was needed for a berm to form and disconnect the Estuary from the ocean. When this model was applied to the flow record from 1982 to 2003, the Estuary was predicted to be closed 31% of the time. It is therefore concluded nutrients loaded to the Estuary in wet weather do not remain in the Estuary because the Estuary is connected to the ocean during high flows.

Based on an assessment of the critical condition, which is the dry season, the linkage analysis for both the Ventura River and Estuary is conducted for dry-weather conditions. Basing the linkage analysis on *dry-weather* loading is a conservative approach to assessing conditions in the *dry season*. Nutrients are loaded from the watershed to the Ventura River and Estuary in both dry and wet weather (Section 4), but the nutrients loaded in the dry season are predominately responsible for the algae, eutrophic conditions, and nutrient impairments in the Ventura River, its tributaries and the estuary.

5.2 Linkage Analysis

5.2.1 Linkage Analysis for the Ventura River

The linkage analysis for the river is based on the River and Stream Water Quality Model (QUAL2K). QUAL2K is used to predict the nutrient concentrations and algal biomass in the various reaches of the Ventura River based on an estimate of watershed-based loading. Only the main stem of the river was modeled due to lack of data for the tributaries. QUAL2K is supported and distributed by the USEPA and has been widely used for studying the impact of conventional pollutants such as nutrients in streams. The QUAL2K model is suitable for simulating the hydrological and water quality conditions of a natural river or stream. It is a simple one-dimensional model that simulates basic stream transport and mixing processes. The processes employed in QUAL2K address nutrient cycles, algal growth, and dissolved oxygen dynamics. The complete description of the QUAL2K model, including model description, calibration and validation analysis, and model results, is included in Appendix B - Technical Memo – Algae and Nutrient Modeling for Ventura River.

5.2.1.1 Ventura River QUAL2K Model Development and Inputs

For modeling, the Ventura River mainstem was divided into 51 computational segments. Headwater data collected by UCSB in 2008 at the confluence of Matilija and North Fork Matilija Creeks (UCSB, 2009) were used to define the upstream boundary conditions for water quality parameters. Average flows from 2001-2008 compiled by Tetratech as part of development of the Ventura River Hydrology Model (Tetratech, 2008) were used to define the upstream boundary conditions for flow. (The model internally calculates the boundary conditions for each downstream segment.) San Antonio Creek, Cañada Larga and Ojai Valley WWTP were modeled as concentrated model inputs. San Antonio Creek and Cañada Larga flow data were obtained from average 2001-2008 data compiled by Tetratech for the 2009 hydrology model and water quality data were obtained from the 2008 UCSB study. For the Ojai Valley WWTP input, NPDES permit data were used to characterize water quality and flow. The watershed-based model inputs for all other sources were obtained from the TMDL source assessment (Section 4). Withdrawal from the Ventura River at Robles Diversion was modeled as an outflow. Meteorological conditions were represented by hourly data obtained from the NOAA weather station in Oxnard.

5.2.1.2 Ventura River QUAL2K Model Calibration and Validation

The model was run based on the inputs described previously. The predicted results of flow and in-stream water quality were compared to a set of data for calibration. The dataset was developed to create a full set of conditions representative of a typical dry-weather day. The water quality calibration data were obtained from the 2008 UCSB study for 14 points throughout the river, and the mean, minimum, and maximum values were calculated for comparison with model-predicted water quality. The model was calibrated for flow, nitrate, TN, phosphate, TP, and benthic algae. Figures 5-2 and 5-3 show the calibration results for flow and nitrate-nitrogen. The model was calibrated by adjusting model parameters to best fit the predicted and measured results.

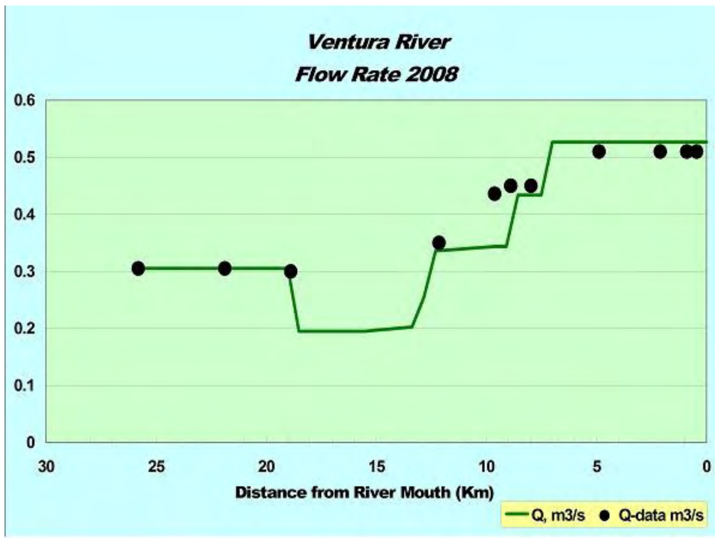

Figure 5-2 Comparison of calculated flow rate with 2008 observed data for calibration

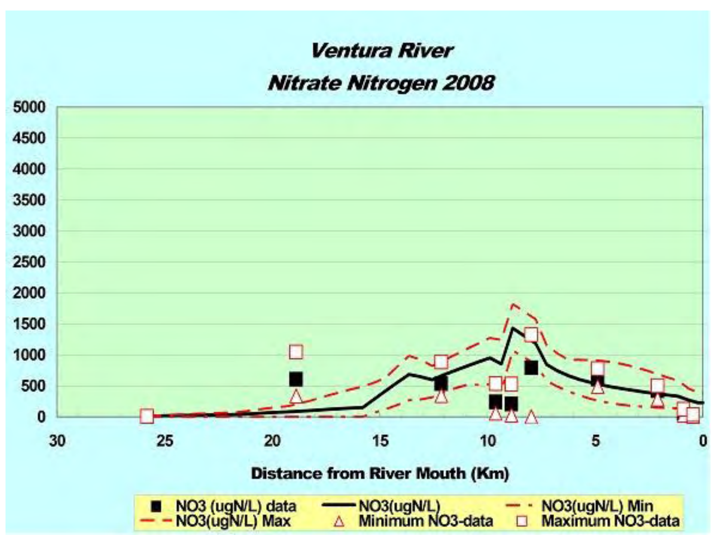

Figure 5-3 Comparison of calculated nitrate-nitrogen with 2008 observed data for calibration

To ensure that the model can reliably predict real situations, two additional sets of measured data, collected by SBCK Stream Team in 2006 and 2007, were used for model validation. The model parameters adjusted during calibration remained the same and only the inputs for San Antonio Creek, Cañada Larga and Ojai Valley WWTP were updated with 2006 and 2007 data. The model was validated for flow, nitrate and phosphate. No validation data were available for TN, TP, or algae. The model results show that flow and nutrient concentrations are validated reasonably well with the measured data (Figures 5-4 to 5-7).

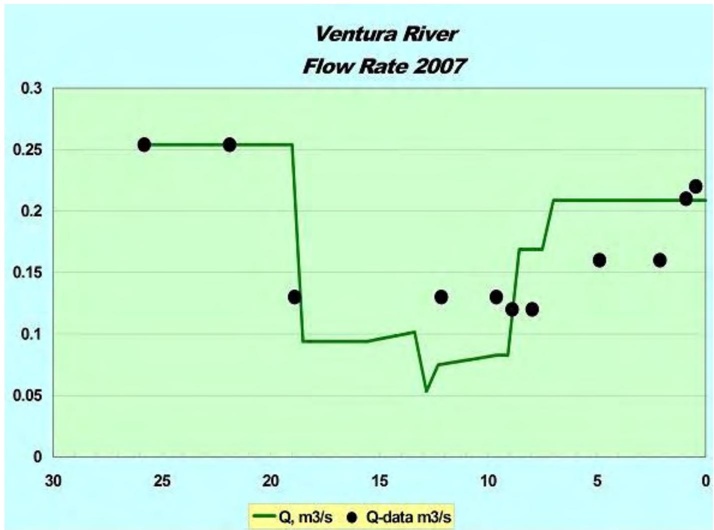

Figure 5-4 Comparison of calculated flow rate with 2007 observed data for validation

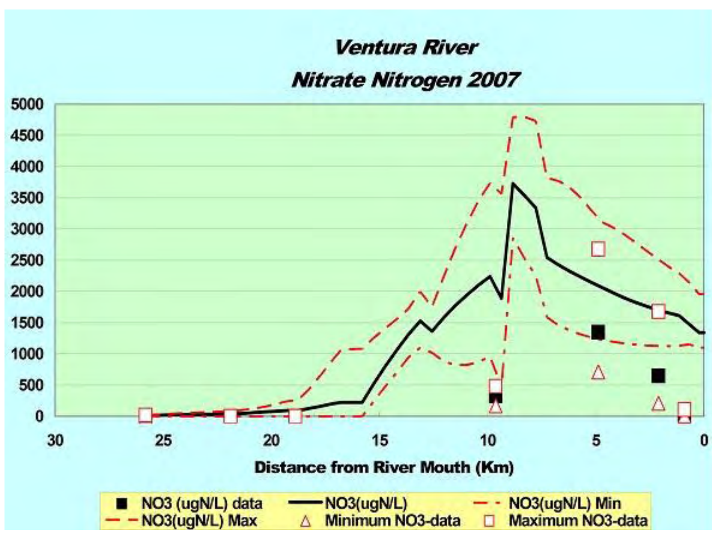

Figure 5-5 Comparison of calculated nitrate-nitrogen with 2007 observed data for validation

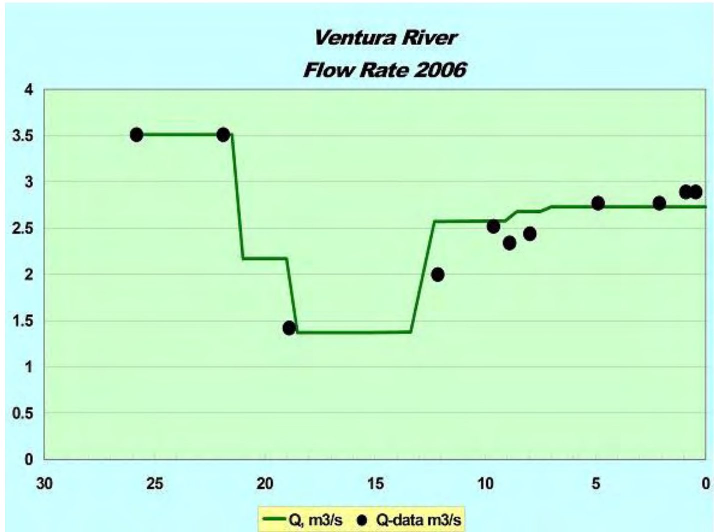

Figure 5-6 Comparison of calculated flow rate with 2006 observed data for validation

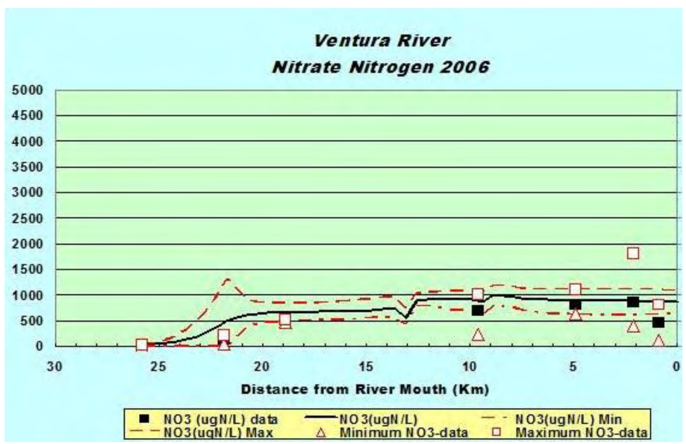

Figure 5-7 Comparison of calculated nitrate-nitrogen with 2006 observed data for validation

The model was able to successfully predict existing conditions (Figures 5-8 and 5-9). The model tracks the trend of in-stream measured water quality data and is approximately equal to the median of measured in-stream concentrations.

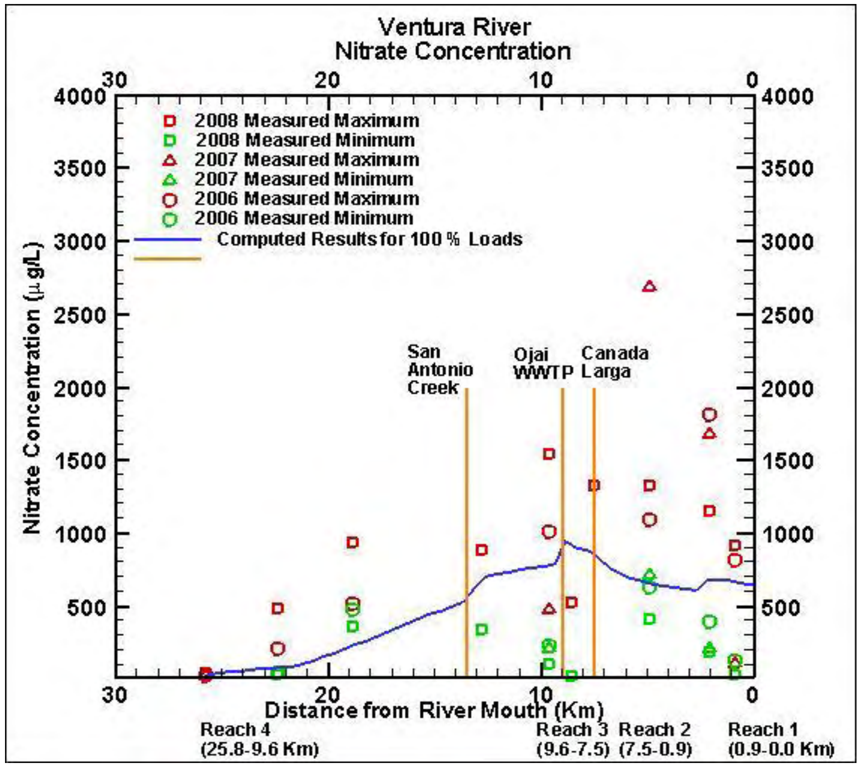

Figure 5-8 Predicted nitrate concentrations based on validated model

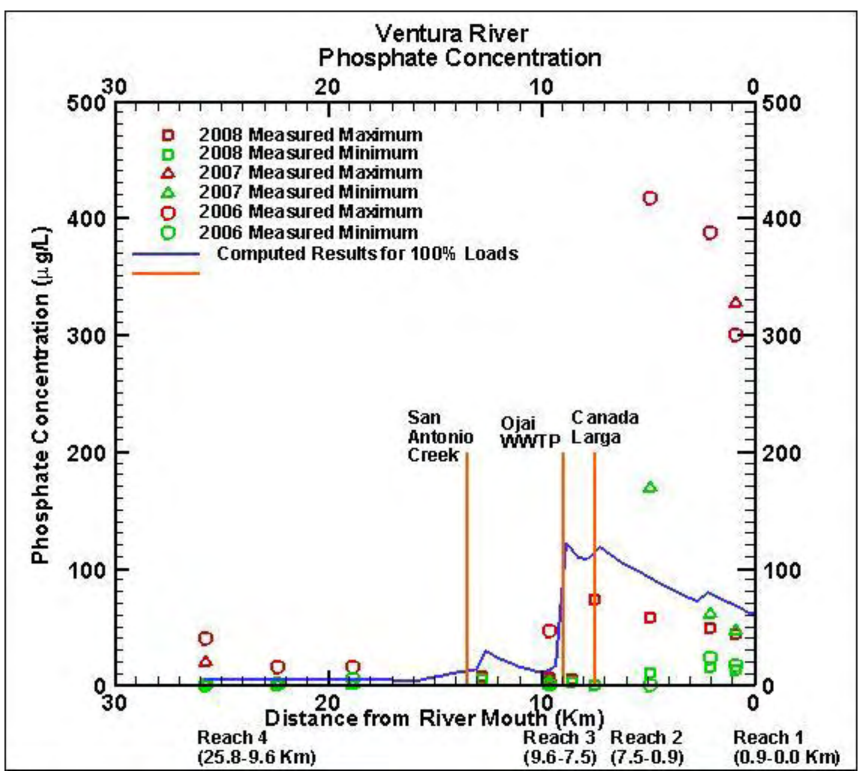

Figure 5-9 Predicted phosphate concentrations based on validated model

The results of the model were used to (1) determine allowable in-stream nutrient concentrations to meet algal biomass targets (Figure 5-10) and (2) evaluate various source reduction scenarios to set dry-weather load and waste load allocations (Section 6). An attempt was made to determine reach-specific relationships between allowable in-stream nutrient concentrations and algal biomass, but there were not enough reach-specific data to establish a significant relationship.

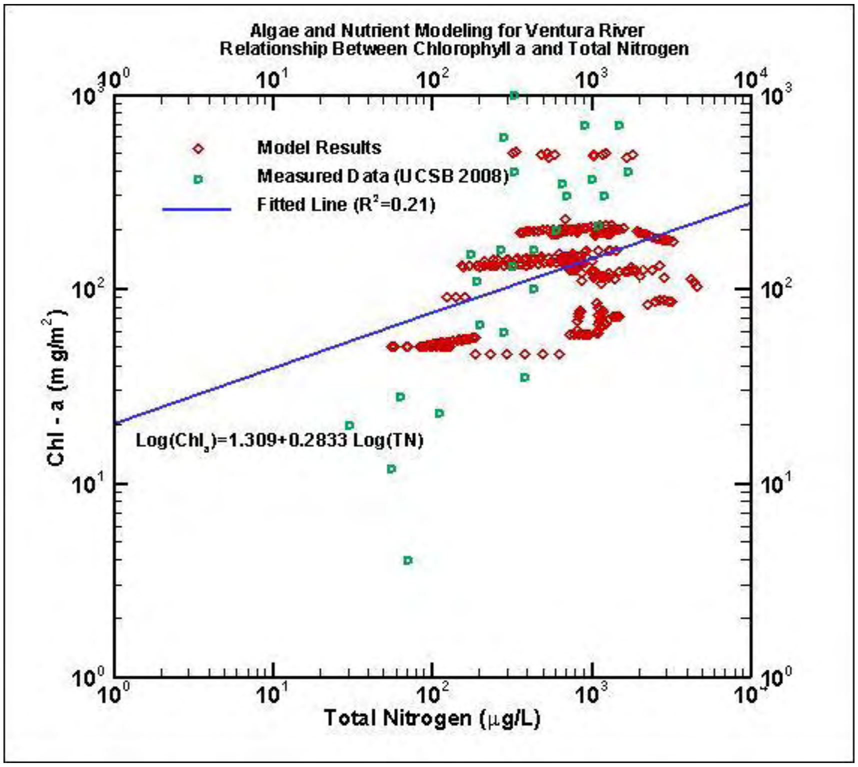

Figure 5-10 Relationship between chlorophyll a and total nitrogen in the Ventura River

5.2.2 Linkage Analysis for the Estuary

The linkage analysis for the Estuary is based on two lines of evidence that establish the relationship between nutrient loading to the Estuary and the resulting nutrient concentrations and algal biomass in the Estuary. The first approach uses the NNE BATHTUB spreadsheet modeling tool to establish the linkage between nutrient loading to the Estuary and the predicted water quality response. The second approach uses empirical relationships between nutrient loading and algal biomass in estuaries developed as part of the Southern California Bight Study 2008.

5.2.2.1 NNE BATHTUB Spreadsheet Modeling Tool

The NNE BATHTUB model was created for application to freshwater reservoirs and lakes. A simplifying assumption is made that the open water portion of the Estuary, formed by the closing of the berm in the late summer and early fall, acts like a freshwater reservoir. It is thus reasonable to apply BATHTUB to the Ventura Estuary during the critical condition.

The NNE BATHTUB spreadsheet tool was developed by Tetra Tech with support by US EPA Region IX and the State Water Resources Control Board. The NNE BATHTUB spreadsheet tool is a user friendly arrangement of the Army Corps of Engineers BATHTUB model (Walker, 1987, 1996) used to analyze the response of lake water quality to different nutrient loading situations. Tetra Tech configured the BATHTUB model to be used in an excel spreadsheet format. The model performs water and nutrient balance calculations under steady-state conditions. Eutrophication related water quality conditions are expressed in terms of total phosphorus, ortho-phosphorus, total nitrogen, inorganic nitrogen, chlorophyll a, transparency (Secchi depth), and hypolimnetic oxygen deletion rates. These conditions are predicted using semi-empirical relationships developed and tested on a wide range of reservoirs.

The following assumptions underlie the linkage analysis. Inputs to the Estuary include nutrient loading from the watershed as estimated by Tetratech by summing flows from Gage 608, Cañada Larga, and the Ojai Valley WWTP and multiplying them by median nutrient concentrations (Tetratech, 2012). Because the Estuary is connected to the ocean during wet-weather when the berm is breached, wet-weather flows do not remain in Estuary. The annual loading to the Estuary is thus assumed to be equal to the annual dry-weather load. During dry weather, evaporation and processes such as sedimentation, resuspension, and nutrient flux alter the concentrations of nitrogen and phosphorus in the Estuary. Nutrients in the system increase over the dry season, until the berm is breached during the following wet-weather season.

The NNE BATHTUB spreadsheet tool allows the user to input physical, chemical, and biological parameters. The input parameters are listed in Table 5-1. The model allows the user to analyze many different nutrient loading scenarios and evaluate the Estuary response. Likewise, the user may specify a chlorophyll-a concentration or change in Secchi depth and the model will predict the probability of exceeding the target under the specified nutrient loading. Additionally, the model will show allowable nitrogen and phosphorus loading combinations to meet the target.

Table 5-1 Bathtub inputs

Parameter	Value
Volume	58,877 m^3
Surface Area	52,602 m^2
Mixed depth	80% of average depth
Evaporation Rate	63 in/ year
Secchi Depth	0.5 meters
Typical Chl-a	9.2 µg/L
TP Load	932 kg
TN Load	7,250 kg
Inorganic N	4,388 kg
Orthophosphate	954 kg
Inflow	6.56 hm^3

The volume and the surface area of the Estuary were calculated in consultation with SCCWRP using remote sensing data. A combination of light detection and ranging (LiDAR) and digital elevation model (DEM) data were used to estimate the bathymetry of the Ventura Estuary (Siebels, 2012, Appendix C).

First, the areal extent of the Estuary was defined based on wetlands polygons developed by SCCWRP using 2005 National Agriculture Imagery Program (NAIP) imagery and attributed using the Cowardin Classification system for wetlands. The polygons developed by SCCWRP were compared to National Wetlands Inventory data to verify the extent of the wetlands in the Ventura River Estuary. The polygons were then revised to delete one "riverine" polygon, redraw one unattributed polygon to align edges, and cut the uppermost polygons to fit the narrative description of the Estuary in Section 1. Although the revised polygons are based on 2005 NAIP imagery, they were also visually compared with 2010 and 2009 NAIP imagery, as well as observations of the Estuary by staff in 2011 and 2012, and historical photos of the Estuary from 1971 to 2010 obtained from the California Coastal Records Project. Based on these comparisons, it is found that the revised polygons present the typical areal extent of the Estuary (Figure 5-11).

Figure 5-11 Areal Extent of the Ventura River Estuary

The revised wetland polygons were then overlaid with LiDAR data to calculate the height of the estuary floor relative to the mean lower low water height. LiDAR data are preferred for estimating the height of the estuary floor because, unlike DEMs that use radar, LiDAR is able to penetrate through the water in the Estuary using light. DEM values were then used to estimate the height of the berm relative to the mean lower low water height. DEM values are preferred for estimating the height of the berm because the data are at a larger scale and average out the height and low points of the berm. The resulting height of the berm was determined to be 2.5 meters. It was assumed that a typical Southern California coastal estuary, when full, is 20 cm below the top of the berm (personal communication, Martha Sutula, SCCWRP, 2012). Thus, the water level of the Estuary is estimated at 2.3 meters. The depth of the Estuary was determined as the water level of the Estuary minus the height of the Estuary floor (Figure 5-12). The resulting volume is presented in Table 5-1.

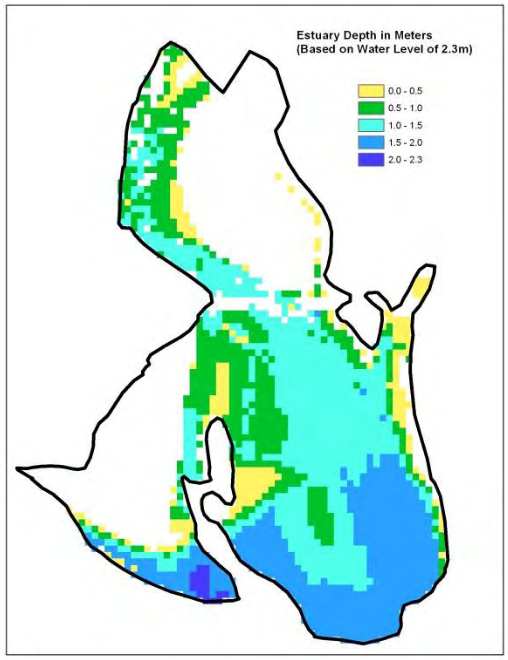

Figure 5-12 Estimated Depth of the Ventura River Estuary

The remaining inputs into the BATHTUB model are discussed as follows. BATHTUB calculates the average depth of the Estuary based on the input area and volume data. The mixing depth was conservatively assumed to be 80%. The evaporation rate was obtained from the El-Rio gage at the United Water Conservation District spreading grounds in Oxnard (Tetratech, 2012). The Secchi depth was based on a measurement collected by Regional Board staff in April 2012 by wading into the Estuary. It is likely that the Secchi depth is greater than the value reported in Table 5-1, and is probably equal to depth of Estuary (i.e., the bottom of the Estuary is visible). The typical chlorophyll a was obtained from an average of one measurement collected by Regional Board staff in April 2012, and two measurements collected by UCSB in 2008 (UCSB, 2009).

The loading and inflow inputs were obtained from the 2012 Tetratech report as previously discussed. The annual nutrient loads were calculated by multiplying the estimated median daily dry-weather loads by the number of dry-weather days in a year (318 days based on Tetratech's assumption that a dry day was any day it did not rain or it did not rain the day before.) The loading inputs obtained from the Tetratech report are lower than the predicted loading based on the freshwater model. (The freshwater model predicts an average load of 140 kg/day.) The loading estimates from the Tetratech report are based on the median dry-weather flow from long-term flow records, which reports lower flows to the estuary as compared to the predicted flows from the freshwater model. The freshwater model predicted load is based on three years of flow data (2006, 2007, and 2008) and tends to over predict nutrient loading due to higher predicted flows. This is because the three years of data used in the freshwater model do not reflect long-term cycles of wet years and drought conditions, as shown in Appendix B. However, the freshwater model does accurately predict in-stream nutrient concentrations; so it is clear that the difference in the loading estimates is related to flow and not nutrient concentrations. The Estuary linkage analysis relied on the Tetratech report as the more accurate of the two loading estimates. The watershed reduction scenarios used to set allocations (Section 6) for the river will result in lower nutrient concentrations delivered to the estuary; thus, there will be an overall reduction in the nutrient load to the estuary.

5.2.2.2 Bathtub Model Results

There were not enough data to calibrate and validate the BATHTUB model for the Ventura Estuary. However, the predicted TN and TP concentrations were compared to limited data on existing TN and TP concentrations in the Estuary, including two samples collected by Regional Board staff in 2011 and 2012 and two samples collected by UCSB in 2008 (UCSB, 2009). The comparisons are shown in Table 5-2.

Table 5-2 BATHTUB-predicted phytoplankton and nutrient concentrations compared to measured nutrient concentrations

Predicted Chl-a µg/L	Predicted TP mg/L	Predicted TN (mg/L)	UCSB TP (mg/L)	UCSB TN (mg/L)	RB 2012 TP (mg/L)	RB 2012 TN (mg/L)	RB 2011 TP (mg/L)	RB 2011 TN (mg/L)
18.0	0.13	1.06	0.07	0.3	0.07	0.3	ND	1.02

As can be seen from Table 5-2, the existing loading from the watershed results in TN and TP concentrations in the Estuary that will attain the phytoplankton numeric target of 20 µg/L.

5.2.3 2008 Southern California Bight Study Relationships between nutrient loading and algal biomass

The second linkage approach for the estuary utilized the empirical relationships between algal biomass and estuarine nutrient loads developed with data from the 2008 Southern California Bight Regional Monitoring Program (Bight ‘08). The Bight ’08 Eutrophication Assessment collected data on both response indicators and nutrient loading in 23 estuaries in southern California from November 2008 through October 2009 (McLaughlin K et al. Bight 2008 Regional Monitoring Program, 2012 Report). Statistical models were used to analyze the data and determine relationships between algal biomass and nutrient loads. Macroalgae and phytoplankton biomass both had significant positive relationships with nutrient loads. These relationships were used to evaluate nutrient loads and expected biological response in the Ventura River Estuary (McLaughlin K et al. Bight 2008 Regional Monitoring Program, 2012 Report).

The Bight ’08 assessment developed several different equations evaluating the strength of various nutrient and algal biomass relationships; the relationships were strongest when estuary volume and residence time were taken into account (McLaughlin K et al. Bight 2008 Regional Monitoring Program, 2012 Report). The equations selected for this linkage analysis were those that predict peak macroalgae biomass and annual average chlorophyll a (phytoplankton biomass). The equation for peak phytoplankton biomass was not used because it was normalized to residence time only. Instead, the equation for average phytoplankton biomass was used because it was normalized for both residence time and volume and is consistent with the equation for peak macroalgae biomass. In addition, the data set for chlorophyll was limited and better suited for predicting an average phytoplankton biomass. The equations are presented below.

$$\log(Peak\ Macroalgae\ Biomass) = [0.15 * \log(\frac{Annual\ TN\ load}{365\ days} * res.time * \frac{1}{Estuary\ Vol})] + 1.7$$

$$\log(Annual\ Avg\ CHLa) = [0.10 * \log(\frac{Annual\ TN\ load}{365\ days} * res.time * \frac{1}{Estuary\ Vol})] + 0.82$$

5.2.3.1 Bight ’08 Empirical Relationship Results

The results from the equations are presented in Table 5-3. The result for predicted annual average chlorophyll *a* is in good agreement with the limited measured data for chlorophyll in the estuary. The annual average chlorophyll *a* measured in the estuary is 9.2 µg/L; this is based on two samples collected by UCSB in the summer of 2008 and one sample collected by Regional Board staff in April 2012.

Additionally, based on thresholds presented in the Scanlan study (2007), described in the numeric targets section, (converted for dry weight, McLaughlin K et al. Bight 2008 Regional Monitoring Program, 2012 Report) estuaries with macroalgae biomass less than 70 grams of dry weight per meter squared are characterized with high to very high water quality at less than 15% cover. The numeric target macroalgae in this TMDL is set at $\leq$ 15 % cover. Thus, the current nutrient loading appears to attain the phytoplankton target for the estuary and limit macroalgae growth to acceptable levels. Moreover, the watershed loading reductions required to protect the river will reduce nutrient concentrations delivered to the estuary and ensure attainment of numeric targets and protection of beneficial uses.

Table 5-3 Predicted biological indicators based on Bight ’08 Empirical Relationships

Biological Indicator	Predicted Result
Peak Macroalgae Biomass	50.8 (g dw/m^2)
Annual Avg. Chl. a	6.7 µg/L

6. POLLUTANT ALLOCATIONS AND TMDLs

This section explains the development of the loading capacity and allocations for nutrients in the Ventura River watershed. EPA regulations require that a TMDL include waste load allocations (WLAs), which identify the portion of the loading capacity allocated to existing and future point sources (40 CFR §130.2(h)) and load allocations (LAs), which identify the portion of the loading capacity allocated to nonpoint sources (40 CFR §130.2 (g)).

6.1 Dry-weather Allocations

As established in the problem statement and the linkage analysis, the critical condition for this TMDL is the dry season and it is loading in the dry season that results in water quality impairments. The allocations are thus primarily focused on dry-weather nutrient loading reductions. Basing the allocations on *dry-weather* loading is a conservative approach to addressing impairments in the *dry season*. Dry-weather is defined as a day with no rain. Wet-weather is defined as any day with rain.

Based on the relationship between nutrient concentrations and algal biomass obtained from the freshwater model (Figure 5-10), the allowable in-stream concentration of TN is equal to 1.15 mg/L. To maintain a balance of nutrients for biomass growth and prevent limitation by one nutrient or another, a ratio of total nitrogen to total phosphorus of 10:1 is used to derive the allowable in-stream concentration of total phosphorus equal to 0.115 mg/L (Thomann, Mueller, 1987).

The dry-weather allocations are based on an evaluation of several source reduction scenarios until one scenario was determined to result in in-stream nutrient concentrations that attain numeric targets for algal biomass, with an explicit margin of safety (Figures 6-1 and 6-2).

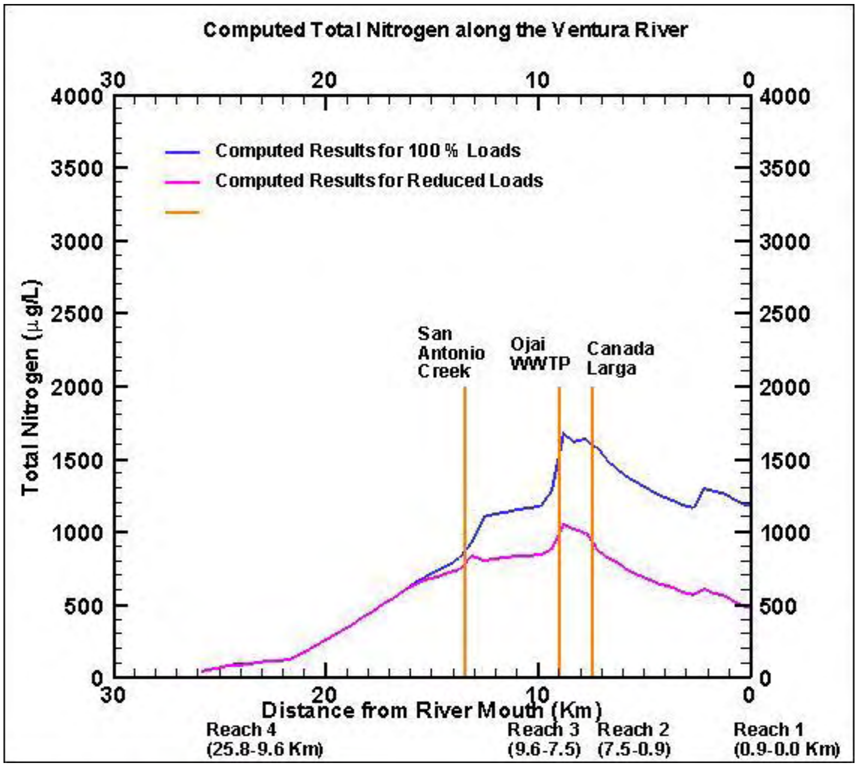

Figure 6-1 TN Reduction scenario to attain allowable in-stream TN concentrations

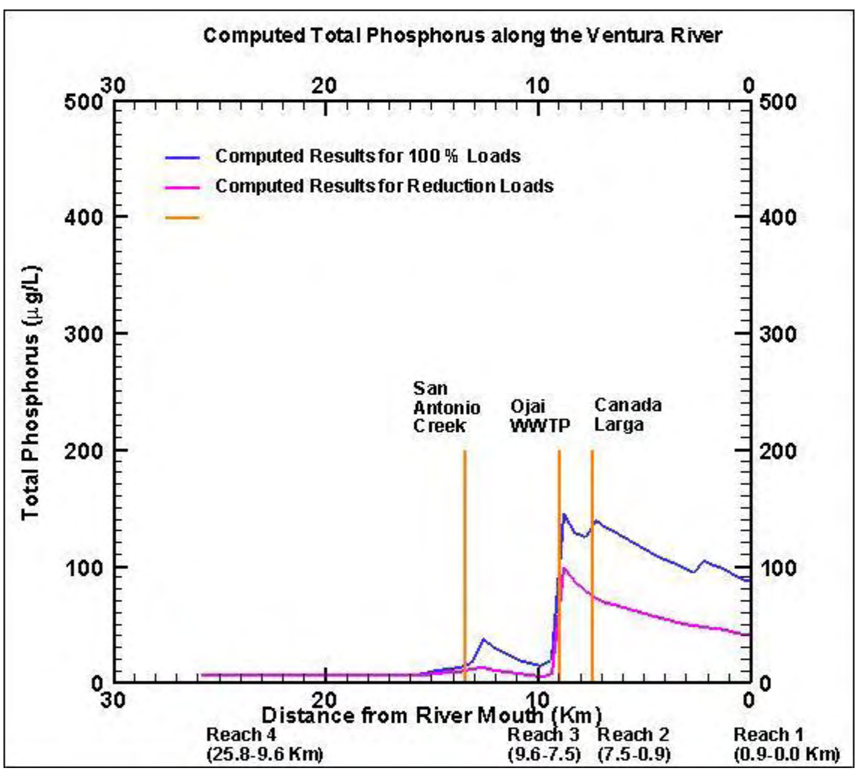

Figure 6-2 TP Reduction scenario to attain allowable in-stream TP concentrations

As described in the critical conditions section (Section 6), water quality impacts are due to watershed-wide loading of nutrients. Therefore, the reduction scenario was designed to reduce loads watershed-wide (Tables 6-1 and 6-2). The feasibility of implementation and the relative source contribution of each source were considered when assigning required load reductions.

Table 6-1 Dry weather WLAs and LAs for TN

Source Type*	Existing Dry-Weather TN Load (lb/total dry days)	Allowable Dry-Weather TN Load (lb/total dry days)	Percent TN Reduction
Dry-weather WLAs for Ventura MS4	18,480	9,240	50%
Dry-weather WLAs for Caltrans	701	350	50%
Dry-weather WLAs for Ojai Valley WWTP	33,984	17,397	49%
Dry-weather LAs for Agriculture	10,389	5,194	50%
Dry-weather LAs for Horses/Intensive Livestock	19,860	199	99%

*Does not include WLAs for OWTS, General Stormwater permits, Grazing Activities, and Other NPDES permits. These WLAs follow in subsequent tables/text.

Table 6-2 Dry weather WLAs and LAs for TP

Source Type	Existing Dry-Weather TP Load (lb/total dry days)	Allowable Dry-Weather TP Load (lb/total dry days)	Percent TP Reduction
Dry-weather WLAs for Ventura MS4	172	86.2	50%
Dry-weather WLAs for Caltrans	70.1	35.0	50%
Dry-weather WLAs for Ojai Valley WWTP	8030	5799	28%
Dry-weather LAs for Agriculture	41.2	20.6	50%
Dry-weather LAs for Horses/Intensive Livestock	4700	47	99%

*Does not include WLAs for OWTS, General Stormwater permits, Grazing Activities, and Other NPDES permits. These WLAs follow in subsequent tables/text.

6.1.1 Dry-weather WLAs for Stormwater Sources

The identified reduction scenario is based on the assumption that TN and TP loading from dry-weather urban runoff from the Ventura County and Caltrans MS4s can be reduced by 50% based on reported removal efficiencies of structural and nonstructural BMPs

(Section 7). The Ventura County MS4 annual monitoring reports document flows of less than 1 cfs at the Ojai and Meiners Oaks outfall monitoring sites. These flows are assumed for Caltrans facilities as well. These flows can be managed by standard structural and nonstructural BMPs that are consistent with the current MS4 permit obligations. Dry-weather WLAs shall be expressed as daily loads based on an estimated 331 dry-weather days per year (Table 6-3).

Table 6-3 Dry-weather WLAs for Ventura County MS4 and Caltrans

Source Type	Dry-Weather WLA (lb/day)
Dry-weather WLAs for Ventura MS4	56
Dry-weather WLAs for Caltrans	2.1

6.1.2 Dry-weather WLAs for general industrial and construction stormwater permittees

The general industrial and construction stormwater permittees are prohibited from discharging non-storm water flows except as authorized by special conditions of statewide general permits. These special conditions require, for example, the inclusion of specific BMPs in pollution prevention plans and the prohibition of significant concentrations of pollutants. Therefore, dry-weather WLAs for general industrial and construction stormwater permittees are equal to the in-stream nutrient concentrations required to meet algal biomass numeric targets (Table 6-4).

Table 6-4 Dry-weather WLA for general industrial and construction stormwater permittees

Permittee	TN (mg/L) (annual dry-weather average)	TP (mg/L) (annual dry-weather average)
General Industrial Stormwater Permittees	1.15	0.115
General Construction Stormwater Permittees	1.15	0.115

6.1.3 Dry-weather WLAs for Ojai Valley WWTP

The dry-weather reduction assigned to Ojai WWTP is based on a report prepared for Ojai WWTP by MWH (2007) that contemplated TN limits equal to 3 mg/L and TP limits equal to 1 mg/L. The required load reduction was calculated by multiplying 3 mg/L TN and 1 mg/L TP by the average daily flow, and then by the total number of dry-weather days in a year as described in Section 4 of the TMDL. Assuming the treatment plant upgrades are implemented as described in their report, the required reductions should be attained.

6.1.4 Dry-weather LAs for Agriculture

The identified reduction scenario is based on the assumption that nutrient loading from dry-weather agricultural runoff can be reduced by 50% based on implementation of irrigation and nutrient management and dry-weather runoff treatment/infiltration BMPs (Section 9). These allocations are consistent with the existing requirements of the Agriculture Waiver adopted as Order No. 2010-0180.

6.1.5 Dry-weather LAs for Horse Facilities and Intensive Livestock Operations

The reduction scenario assumes the elimination of dry-weather runoff from horse and intensive livestock facilities, represented as 1% of the existing load. As described in the source assessment section of the TMDL (Section 4), the estimated nutrient loading from horse facilities also approximates the nutrient loading from intensive livestock operations. Therefore, the source reductions for horse and intensive livestock facilities are jointly assigned. Nutrient contributions from horse and intensive livestock facilities are manageable in dry weather, considering the scale of the operations in the Ventura River watershed and the effectiveness of manure management practices at reducing dry-weather loading.

6.1.6 Dry-weather LAs for Grazing Activities

Dry-weather load reductions for grazing activities have not been quantified because their existing loading was not quantified. However, they are assigned a percent reduction of their existing TN and TP load equal to 10%. The existing load will be quantified as part of management plans required to implement the TMDL (see Section 7).

6.1.7 Dry- and Wet-Weather LAs for OWTS

LAs for OWTS were calculated based on an assumed reduction of TN loading equal to 50% based on requirements in the State Water Resources Control Board Policy for OWTS for supplemental treatment of certain OWTS in Tier 3, Impaired Areas. The resulting allowable load from OWTS is 7,478 pounds TN per year. The LAs apply in dry and wet weather. No LAs are assigned to OWTS for TP.

6.1.8 Dry- and Wet-weather WLAs for Other NPDES Permittees

Dry-weather WLAs for other NPDES permittees are equal to the in-stream nutrient concentrations required to meet algal biomass numeric targets of 1.15 mg/L TN and 0.115 mg/L TP. Wet-weather allocations are set to attain site-specific nitrogen water quality objectives from Table 3-8 of the Basin Plan (Table 6-4). There are no site-specific objectives for Reach 1 or the Estuary, nor are there any “Other NPDES permittees” that discharge to Reach 1 or the Estuary. Thus, there are no wet-weather WLAs assigned to Other NPDES permittees for Reach 1 or the Estuary.

6.2 Wet-weather Allocations

6.2.1 Wet-weather allocations for Stormwater, Agriculture, and Horse/Livestock Sources

Based on the linkage analysis, wet-weather loads do not have a significant impact on receiving water quality in the Ventura River and its tributaries or the Estuary and biostimulatory objectives are attained. Thus, wet-weather allocations are set to attain site-specific water quality objectives from Table 3-8 of the Basin Plan (Table 6-5). There are no site-specific objectives for Reach 1 or the Estuary. For Reach 1 and the Estuary, wet-weather WLAs for stormwater sources are equal to existing water quality in stormwater discharges (maximum TN = 4.6 mg/L from Table 4-5) and LAs for agriculture and horse/livestock sources are equal to benchmarks of 10 mg/L nitrate-N + nitrite-N in the Agriculture Waiver.

Table 6-5 Wet-weather Allocations

Reach	Nitrate-N + Nitrite-N (mg/L)
Estuary	*
Reach 1	*
Reach 2	10
Cañada Larga	10
Reach 3	5
San Antonio Creek	5
Reach 4	5
Reach 5	5
*WLAs for stormwater are equal to 4.6 mg/ L TN and WLAs for agriculture and horse/livestock sources are equal to 10 mg/L nitrate-N + nitrite-N.	

6.2.2 Wet-weather Allocations for Ojai Valley WWTP

In wet-weather conditions, the biological performance of treatment operations at the Ojai Valley WWTP may be reduced due to lower temperatures and loading may increase due to increased inflows. Therefore, during wet-weather events, concentration-based WLAs are based on the 90^{th} percentile of existing performance of the facility since 2000 (Table 6-6).

Table 6-6 Ojai Valley WWTP Wet-weather WLAs

TN (mg/L)	TP (mg/L)
7.6	2.6

6.3 Margin of Safety

The sources of uncertainty in this TMDL are related to the selection of the algal biomass target, the relationship between nutrient concentrations and algal biomass in freshwater river systems and estuaries, the estimate of watershed-based nutrient loading, and the model-predicted water quality conditions in the receiving water. These areas of uncertainty are addressed with both an implicit and explicit margin of safety.

The implicit margin of safety includes conservative assumptions made when estimated watershed-based nutrient loading. For example, the nitrate and phosphate concentrations used to estimate dry-weather loading from agriculture is based upon measured data from an area more intensely farmed (and having tile drains, which concentrate nutrients) than in the Ventura River watershed. The flows for Canada Larga and San Antonio Creek were higher than the median flows obtained from long-term flow records. This overestimates the loading into the main stem of the river and conservatively predicts main stem nutrient concentrations. Finally, basing the allocations on dry-weather loading is a conservative approach to addressing impairments in the dry season.

The explicit margin of safety is calculated as the difference between the model-predicted maximum concentration in-stream after implementation of reduction scenarios and the desired in-stream concentrations of 1.15 mg/L TN and 0.115 mg/L TP. The resulting explicit margin of safety is 8%. This explicit margin of safety is applied to account for uncertainty in the algal biomass numeric target of 150 mg/L and the relationship between the required in-stream nutrient concentrations necessary to attain this value. This explicit margin of safety also addresses the fact that the model-predicted nutrient concentrations are reflective of median measured concentrations, and do not capture not maximum concentrations (Figures 5-8 and 5-9).

7. IMPLEMENTATION

This section describes the regulatory mechanisms that will be used to implement the TMDL, how compliance with WLAs and LAs will be determined, implementation measures that could be used to attain WLAs and LAs, and an implementation schedule. This section also includes a discussion of monitoring requirements, special studies that may be conducted to evaluate assumptions in the TMDL, and a consideration of costs of the reasonably foreseeable methods of compliance with the TMDL.

7.1 Implementation of WLAs

The regulatory mechanisms used to implement the WLAs include the Ojai Valley WWTP NPDES permit, the Ventura County MS4 NPDES permit, the Caltrans MS4 NPDES permit, the general industrial storm water permits, the general construction storm water permits, and other NPDES permits. WLAs shall be incorporated into each permit at the time of permit issuance, modification, or renewal of the permit.

7.1.1 Ojai Valley WWTP

The dry-weather WLAs for the Ojai WWTP shall be incorporated into the permit as numeric effluent limitations, expressed as a dry-weather load, calculated as the monthly nutrient concentration (TN and TP) multiplied by the daily flow for each dry-weather day, and summed over an annual period. The wet-weather WLAs shall be incorporated as numeric effluent limitations, expressed as a daily maximum concentration, to be assessed at a minimum with monthly sampling. Ojai WWTP shall achieve compliance with wet-weather WLAs upon incorporation into the permit and shall achieve compliance with dry-weather WLAs within 10 years of the effective date of the TMDL. Ojai Valley WWTP shall have interim dry-weather WLAs based on current plant performance (90^{th} percentile of the last twelve years of data); i.e., equal to wet-weather WLAs (Table 7-1).

Table 7-1 Ojai Valley WWTP interim dry-weather WLAs

TN (mg/L)	TP (mg/L)
7.6	2.6

7.1.2 Ventura County MS4 and Caltrans

The WLAs for the Ventura County MS4 permittees and Caltrans shall be incorporated into the permit as numeric water quality-based effluent limitations. Wet-weather numeric effluent limitations shall be expressed as event mean concentrations and shall apply immediately upon issuance, modification, or renewal of the permits. Compliance with wet-weather WLAs shall be assessed at a minimum with two wet-weather sampling events. Dry-weather WLAs shall be assessed at a minimum with quarterly sampling and shall be attained within 6 years.

Ventura County MS4 permittees and Caltrans shall provide an implementation plan to the Regional Board outlining how they intend to achieve compliance with the WLAs. The report shall include implementation methods, an implementation schedule, proposed interim milestones, and compliance points.

7.1.3 General Industrial and Construction Stormwater Permittees

The dry- and wet-weather WLAs for the general and industrial stormwater permittees shall apply immediately upon issuance, modification, or renewal and shall be incorporated into permits as numeric effluent limitations. Wet-weather numeric effluent limitations shall be expressed as event mean concentrations and dry-weather numeric effluent limitations shall be expressed as instantaneous maximums. Dry- and wet-weather WLAs shall apply immediately upon issuance, modification, or renewal. Compliance with wet-weather WLAs shall be assessed at a minimum with one wet-weather sampling event. Compliance with dry-weather WLAs shall be assessed at a minimum by averaging the results of two grab samples.

7.1.4 Other NPDES Permittees

The dry- and wet-weather WLAs for other NPDES permittees shall apply immediately upon issuance, modification, or renewal of applicable permits and shall be incorporated into permits as numeric effluent limitations. Wet-weather numeric effluent limitations shall be expressed as event mean concentrations and dry-weather numeric effluent limitations shall be expressed as instantaneous maximums. Dry- and wet-weather WLAs shall apply immediately upon issuance, modification, or renewal of relevant permits. Compliance with wet-weather WLAs shall be assessed at a minimum with one wet-weather sampling event. Compliance with dry-weather WLAs shall be assessed at a minimum with two grab samples.

7.2 Implementation of LAs

Two primary federal statutes establish a framework in California for addressing nonpoint source water pollution: Section 319 of the Clean Water Act (CWA) of 1987 and Section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA). In accordance with these statutes, the state assesses water quality associated with nonpoint sources of pollution and develops programs to address nonpoint sources. The *Plan for California's Nonpoint Source Pollution Control Program* (NPS Program Plan), which became effective in 2000, provides a coordinated statewide approach to dealing with nonpoint source pollution. Federal approval of the NPS Program Plan required the State Water Resources Control Board (SWRCB) to provide assurances that it has the legal authority to implement and enforce the NPS Program Plan. In 2004, the SWRCB adopted the Nonpoint Source Implementation and Enforcement Policy. This policy specified that the regional boards have the administrative permitting authorities to regulate nonpoint sources of pollution through Basin Plan prohibitions, waste discharge requirements (WDRs), and waivers of WDRs. The regulatory mechanisms that will be used to implement LAs for each source category are described below.

7.2.1 Agricultural Discharges

The LAs for irrigated agricultural lands shall be implemented through the Agriculture Waiver or other appropriate Regional Board order. Under the existing Agriculture Waiver (Order No. 2010-0180), growers are required to monitor discharges and, if water quality exceeds objectives, growers are required to develop a water quality management plan and implement best management practices (BMPs) to attain objectives. Each owner and/or operator of irrigated agricultural lands in the Ventura River Watershed shall be required to enroll in the Agriculture Waiver or other Regional Board order in order to comply with the LAs. Agricultural lands shall achieve compliance with dry- and wet-weather LAs within 6 years of the effective date of the TMDL.

The existing monitoring program for the Agriculture Waiver includes two monitoring sites in the upper watershed that monitor runoff from orchards. To implement the LAs in this TMDL, the monitoring program shall be revised to add representative sites in the lower watershed to monitor runoff from other crop types. The revised monitoring program shall be subject to approval by the Executive Officer of the Regional Board.

7.2.2 OWTS

The LAs for OWTS shall be implemented through prohibitions, WDRs, or waivers of WDRs. Commercial and multifamily OWTS are currently regulated by the Regional Board through WDRs. Single family residential OWTS are currently regulated by the City of Ojai, the City of Ventura, and the County of Ventura, as specified in memorandums of understanding (MOUs) with the Regional Board, in order to implement a waiver of WDRs for single family residential OWTS adopted by the Regional Board in 2004. The MOUs require the Regional Board to evaluate the local agency every five years to ensure their municipal plumbing code and OWTS program is substantially equivalent to any statewide standards adopted pursuant to CWC sections 13290 and 13291.

CWC sections 13290 and 13291 require that the SWRCB adopt statewide regulations for the permitting and operation of OWTS (OWTS Policy). SWRCB adopted a policy to comply with CWC sections 13290 and 13291 on June 19, 2012. The OWTS Policy will become final once it is approved by the Office of Administrative Law. The policy emphasizes local management of OWTS. The policy requires an Advanced Protection Management Program and local agencies are authorized to implement Advanced Protection Management Programs in conjunction with their existing programs and in collaboration with the Regional Board. The geographic area for the Advanced Protection Management Programs to implement this TMDL shall be the entire Ventura River watershed because the TMDL applies to all reaches and tributaries of the Ventura River and because of the demonstrated connectivity between groundwater and surface water throughout the watershed.

The OWTS in the Ventura River watershed fall under Tier 3 of the OWTS Policy. The Regional Board will work with local agencies to determine which individual OWTS or areas of OWTS are contributing to the overall loading from OWTS as described in the source assessment (Section 4). The Regional Board will evaluate the MOUs with the City of Ventura, the City of Ojai, and the County of Ventura to determine if their OWTS programs need to be updated to reflect the OWTS Policy, or if additional changes are needed to implement the LAs. OWTS dischargers shall achieve compliance with dry- and wet-weather LAs within 10 years of the effective date of the TMDL.

7.2.3 Horse and Livestock Activities

The LAs for horse and livestock facilities shall be regulated by WDRs or waivers of WDRs. It is expected that a waiver program similar to the Agriculture Waiver will be adopted for horse and livestock activities. As part of the proposed program, horse and livestock facilities shall be required to conduct monitoring and develop management plans that will assess baseline water quality discharged from their facilities, determine reductions needed to attain LAs, and implement management measures to attain LAs.

Compliance with LAs will be demonstrated at monitoring sites approved by the Executive Officer of the Regional Board through the monitoring program developed as part of the waiver or WDR, or through a monitoring program that is required to implement this TMDL in the event a waiver or WDR is not adopted in accordance with the TMDL implementation schedule. Horse and livestock facilities shall achieve compliance with dry- and wet-weather LAs within 10 years of the effective date of the TMDL.

7.3 Potential Implementation Strategies and Associated Costs

The TMDL requires responsible parties to attain WLAs and LAs for nutrients to prevent excessive algal growth and maintain adequate dissolved oxygen concentrations and pH values in the Ventura River and its tributaries. There are many implementation alternatives available to reduce nutrient loading. Rather than a single treatment solution, a combination of implementation measures may be required to reduce nutrients and algae to acceptable levels. The following discussion presents several potential implementation strategies that could be used to comply with the TMDL and their associated costs.

The cost estimates for the potential implementation actions are intended to provide the Regional Board with a reasonable range of potential costs of implementing this TMDL. The cost estimates are not additive; rather, responsible parties may implement individual potential treatment alternatives or a combination of alternatives and the costs would vary accordingly. The cost estimates account for a range of economic factors and require a number of assumptions regarding the extent of implementing many of the measures. In reviewing the cost estimates, it should be noted that there are multiple additional benefits associated with the implementation of these strategies. Many of the structural and non-structural BMPs to address nutrient loadings could also reduce the loading of other contaminants, which could assist in meeting the requirements of other existing or future Ventura River TMDLs.

7.3.1 Waste Water Treatment Plant Upgrades

7.3.1.1 Upgrading Nitrification-Denitrification (NDN) Processes at Ojai Valley WWTP

The Ojai Valley WWTP currently operates with advance secondary treatment including nitrification and denitrification. Three alternatives have been previously considered by the Ojai Valley Sanitation District to upgrade the WWTP in order to decrease nutrient discharges (MWH, 2007). The first two options consider a total nitrogen limit of 3mg/L, and a phosphorus limit of 1mg/L. The third scenario considers a total nitrogen limit of 1mg/L and a phosphorus limit of 0.1mg /L. The first two alternatives are presented here based on the WLAs for the Ojai WWTP equal to 3 mg/L TN and 1 mg/L TP.

7.3.1.2 Conversion to Modified Bardenpho process

The first alternative to improve the plant's denitrification capacity is to convert the existing three stage process (comprised of successive anaerobic, anoxic and anaerobic zones) to a five-stage Modified Bardenpho process. The upgrade consists of the addition to the existing process of a second (post-aeration) anoxic zone, including inclusions of carbon in the form of methanol to increase denitrification, followed by a third aerobic zone. The capital cost for this option is estimated to be 16.6 million dollars, with operation and maintenance costs of $205,000 annually (adjusted to 2012 dollars).

7.3.1.3 Addition of denitrification filters

The second proposed implementation alternative is the addiction of denitrification filters to the existing facilities, a process that serves the dual purpose of denitrification and filtration of suspended solids. The heterotrophic microorganisms cultivated on the Granular media denitrification filters will require methanol addition as a source of carbon to sustain growth. The estimated construction cost is 17.2 million dollars and the maintenance cost is $270,000 per year (adjusted to 2012 dollars).

With either of these alternatives optimization of phosphorus removal can be added. Based on the MWH (2007) report the facility has capabilities to include alum or other coagulant treatments.

7.3.2 Urban Runoff Implementation Alternatives

7.3.2.1 Biofilter systems

Biofilters, also known as vegetated swales and filter strips, are vegetated slopes and channels designed and maintained to transport runoff slowly over vegetation. The slow movement of runoff through the vegetation provides an opportunity for sediments and particulates to be filtered and degraded through biological activity. In most soils, the biofilter also provides an opportunity for infiltration of dry-weather runoff and storm water, which further removes nutrients and reduces runoff volumes. Swales convey flows to a vegetation-lined channel and grass filter strips intercept sheet runoff to a uniformly graded buffer zone. Grass strips and vegetated swales can function as pretreatment systems for water entering bioretention systems or other BMPs. These can be installed as on-site features of developments or in street medians, parking lot islands, or curb extensions (CASQA, 2003). Biofilters can be used to effectively reduce nutrient loading; the range of removal efficiency is 20 – 80 percent (CASQA, 2003).

Vegetated swales or filter strips, based on case studies, are capable of managing runoff from small drainage areas with approximate sizes of 10 acres. Considering a unit swale that is 10 feet wide and 1,000 feet long, which results in a hydraulic residence time of at least 10 minutes, for each 10 acres of drainage area, the ratio of the swale surface area to each draining acre, is 1,000 square feet per acre (CASQA, 2003). The mid-range cost to construct a swale for treatment of a 10-acre drainage area is $20,000 (adjusted to 2012 dollars) (CASQA, 2003). The annual maintenance cost is estimated at 5% (Table 7-2).

Table 7-2 Summary of vegetated swales costs

Items	Unit Cost (per 10-acre drainage area)
Capital Cost	$20,000
Operation and Maintenance Cost	$100

7.3.2.2 Alum Injection Systems to treat urban runoff

Alum injection systems are another treatment option for dry weather or stormwater runoff. Alum injection is the process of adding aluminum sulfate salt (alum), to stormwater prior to discharge into the river. The systems can be installed and sited at appropriate locations in the watershed. Alum fixes itself to common pollutants, such as phosphorus, and the floc settles from the water column. Studies of the effectiveness of nutrient removal report 30 - 90 percent removal for nitrogen and phosphorus.

Parameters to be considered for design of the automated alum injection system include the stormwater drainage area, flow rate of stormwater discharge, locations of the system, and the seasonal precipitation. The construction cost for a drainage area of 1,500 acres ranges from $100,000 to $550,000 with the average capital cost of $2,100 per acre treated (adjusted to 2012 dollars). The overall operation and maintenance cost ranges from $37 to $287 per acre treated per year, with an average of $166 dollars per acre per year (Harper, Herr, Livingston, 1999) (Table 7-3).

Table 7-3 Summary of alum injection costs

Items	Unit Cost
Capital Cost	$2,100 per acre
Operation and Maintenance Cost	$166 per acre per year

7.3.2.3 Constructed wetlands

Constructed treatment wetlands are designed to maximize the removal of pollutants from storm water and dry-weather urban runoff through settling and uptake and filtering by vegetation. Constructed wetlands temporarily store runoff in a shallow marsh that support conditions suitable for the growth of wetland plants. These excess nutrients are absorbed by wetland soils and taken up by plants and microorganisms. The treatment efficiency of constructed wetlands varies considerably (TN 26% $\pm$ 49%, TP 43% $\pm$ 40%); however, proper design and maintenance helps to improve their performance (US EPA, 2003a).

CASQA (2003) reports an estimated cost of wetland installation for a 100 acre-foot facility of $1,800,000 (adjusted to 2012 dollars). Annual operation and maintenance costs are estimated at 5% of the construction cost (Table 7-4).

Table 7-4 Summary of storm water constructed wetland costs

Items	Unit Cost
Capital Cost	$18,000 per acre
Operation and Maintenance Cost	$900 per acre per year

7.3.2.4 Non-structural BMPs

Non-structural BMPs include educational and pollution prevention practices. Several nonstructural BMPs are listed below.

- Prohibition of non-stormwater discharges to the MS4
- Increased cleaning of catch basin inlets and open channels
- Public education and outreach
- Illicit connection and discharge prevention

The costs for a number of non-structural measures have been estimated for the entire Los Angeles Region (Devinny et al., 2004), which has an area of 3,100 square miles. The source control measure costs for the Ventura River watershed were scaled down proportionally. The Ventura River watershed is approximately 228 square miles. The watershed has 17.9 square miles of urban area that could need to be treated to comply with the TMDL. The following represent the approximate values for the Ventura River watershed for source control measures based on the Devinney et al., study:

- Public education - $28,871 per year
- Increased storm drain cleaning - $155,903 per year

The prohibition of non-stormwater discharges and the illicit connection elimination programs are existing MS4 programs and the costs were not estimated.

7.3.3 Agriculture Implementation Alternatives

7.3.3.1 Filter Strips

NRCS estimates that filter strips planted with native plant material are $1,031 per acre of filter strip installed. Staff estimated a ratio of treated agricultural land area to filter strip area of 60:1 using design methods described in *Design of Stormwater Filtering Systems* (CWP, 1996) and assuming a 99% pervious drainage area, a 1-inch storm, a minimum filter strip length of 25 feet, a berm height of six inches, and a 150-foot by 150-foot drainage area.

The calculated 60:1 ratio is consistent with the NRCS Conservation Practice Standard for Filter Strips (Code 393), which specifies that the ratio of the drainage area to filter strip area shall be less than 60:1 in regions with RUSLE-R (Revised Universal Soil Loss Equation- Rainfall-Erosivity) factor values of 35-175 (RUSLE-R factor values for California range from 60-100).

Assuming a ratio of treated agricultural land area to filter strip area of 60:1, the cost of filter strips is $17 per acre of agricultural land treated. According to Code 393, filter strips should be designed to have a 10-year lifespan. Assuming a 10-year lifespan and a 5 percent discount rate, the equivalent annual cost of filter strips is $2 per acre-year.

7.3.3.2 Mulching

NRCS estimates that mulching costs $808 per acre of mulch applied. The NRCS Conservation Practice Standard for Mulching (Code 484) specifies that mulching should be applied at a rate to achieve a minimum of 70 percent ground cover to provide erosion control. Therefore, the cost of mulching is $566 per acre of agricultural land treated.

According to the NRCS Field Office Technical Guide (FOTG) for mulching, the reported lifespan for this practice is one year, but local NRCS staff has reported that woody mulch can last two to three years and mulch residue can last up to five years. Assuming a lifespan of three years and a 5% discount rate, the equivalent annual cost of mulching is $208 per acre-year.

7.3.3.3 Improved Irrigation Efficiency and Nutrient Management

Often replacing a traditional irrigation system with a drip irrigation system can reduce nutrient runoff. Improved maintenance of the systems may further reduce farm runoff. Costs for installing and maintaining micro-irrigation systems vary according to the type of production found in the watershed (NRCS FOTG Cost Data 2010; see Table 7-5 below). On average, the installation cost is $1784 per acre, with a maintenance cost of $84.

Table 7-5 Summary of micro-irrigation costs

Items	Unit Cost
Nursery or greenhouse	
Capital Cost	$3,006 per acre
Operation and Maintenance Cost	$150 per acre per year
Lifespan	10 years
Orchard or vineyard > 10 acres	
Capital Cost	$1406 per acre
Operation and Maintenance Cost	$70 per acre per year
Orchard or vineyard < 10 acres	
Capital Cost	$2006 per acre
Operation and Maintenance Cost	$100 per acre per year
Row/field cropland. Buried manifold	
Capital Cost	$1506 per acre
Operation and Maintenance Cost	$75 per acre per year
Row/field cropland. Layflat manifold	
Capital Cost	$996 per acre
Operation and Maintenance Cost	$50 per acre per year
AVERAGE	
Capital Cost	$1784 per acre
Operation and Maintenance Cost	$89 per acre per year

The NRCS cost estimate for a nutrient management plan is $55 per acre-year (NRCS FOTG Cost Data, 2010).

7.3.3.4 Manure Management

Manure management requires horses and/or livestock owners to collect, store, and dispose of manure in a manner that minimizes nutrient contributions to the river. One method to properly store manure is to construct manure bunkers that prevent stormwater and dry-weather runoff from carrying nutrients to the river. The average cost to construct a manure bunker is $4,500 (Ecology Action, personal communication, in CRWQCB 2009; adjusted to 2012 dollars). This cost applies to bunkers constructed on an existing cement slab, or a where a new one was poured, and includes a permanent roof or a tarp cover. The cost of bunkers varies depending on the size and materials, and ranges from $3000 to $17,000.

7.3.3.5 Grazing Management

Grazing management protects stream banks, riparian zones, and minimizes nutrient contributions to the river and tributaries. Grazing management includes using fencing, stream crossings, and providing alternative drinking locations in order to exclude livestock from sensitive areas. Grazing management can also reduce upland erosion through prescribed grazing, seeding, and gully erosion control which utilizes grade stabilization and ponds. Federal land managers (i.e. Bureau of Land Management, Forest Service) have plans with recommendations for grazing management practices (US EPA, 2003b).

Preventing horses and cattle access to waterways requires the installation of fences along portions of streams susceptible to damage and installation of watering facilities to provide an alternative water source for the animals. An average installation cost of fencing is $6 per feet. The costs range depending on the type of fencing from $2.20 – $11.70 (Table 7-6).

Table 7-6 Summary of fencing costs

Items	Unit Cost
Conventional	
Capital Cost	$4.5 per feet
Operation and Maintenance Cost	$0.1 per feet per year
Electric	
Capital Cost	$2.2 per feet
Operation and Maintenance Cost	$0.1 per feet per year
Woven wire	
Capital Cost	$11.7 per feet
Operation and Maintenance Cost	$0.2 per feet per year
AVERAGE	
Capital Cost	$6.1 per feet
Operation and Maintenance Cost	$0.1 per feet per year

The demand for alternative water facilities is related to the size of the ranching operation; unit cost for watering facilities varies based on volume (Table 7-7). The average cost of a typical watering facility is $1,356.

Table 7-7 Summary of watering facilities costs

Items	Unit Cost
2,501-5,000 gal	
Capital Cost	$2,413 per unit
Operation and Maintenance Cost	$46 per unit per year
601-2,500 gal	
Capital Cost	$1529 per unit
Operation and Maintenance Cost	$30 per unit per year
300-600 gal	
Capital Cost	$991 per unit
Operation and Maintenance Cost	$13 per acre per year
<300 gal	
Capital Cost	$491 per unit
Operation and Maintenance Cost	$9 per unit per year
AVERAGE	
Capital Cost	$1356 per unit
Operation and Maintenance Cost	$25 per unit per year

7.3.4 Anaerobic Biodigester Systems

Manure produced by horses and livestock can be converted to biogas for renewable source of energy. The biodigester mixes organic wastes and manure with water and bacteria. During anaerobic digestion, bacteria break down organic wastes and manure in an oxygen-free environment.

The Waste to Energy project team is proposing to build an anaerobic digester in the Ojai Valley (W2E) to convert organic wastes produced in the area to energy (electricity/biogas), compost, and liquid fertilizer (W2E, 2010). The solid organic wastes in the Ojai Valley are estimated to be 30-70 tons/day; the proposed biodigester, with a capacity of 50-75 tons/day, could potentially treat the majority this waste. The estimated construction costs for the plant are 6 to 8 million dollars (W2E, 2010) and subsequent annual costs for a 50 tons/day plant (scaled up from the 31 tons/day biodigester at UC Davis) are estimated to be about $420,000 annually. Annual revenues could total $725,000 per year based solely on sale of power. Accordingly, the payback period for the capital would be 5 to 10 years (Table 7-8).

Table 7-8 Summary of anaerobic biodigester systems costs

Items	Total Cost
Capital Cost	$6,000,000 to $8,000,000
Operation and Maintenance Cost	$420,000 annually
Revenue	$725,000 annually

7.3.5 OWTS Inspections and Upgrades

Various actions may be required to reduce the loading from OWTS. These may include actions ranging from inspection or regular monitoring to the installation of supplemental treatment. An assessment of a site to determine if a particular OWTS is contributing to surface water loading of nutrients could cost as much as $5,000 dollars. The Regional Board will work with local agencies to utilize existing monitoring wells and data to the extent practicable in order to reduce costs. If testing confirms the need for advanced treatment, the cost of upgraded systems could cost up to $22,000 dollars (SWRCB, 2012). There would also be ongoing maintenance and monitoring requirements to ensure the advanced treatment is performing well.

The cost of compliance for OWTS owners will depend on the type of system and the capacity of the system. Local agencies will likely incur additional costs to the extent that they need to revise their existing programs or practices. These local agency costs may be passed on to OWTS owners in the form of permit fees.

The relatively high costs of supplemental treatment OWTS may make the option of connecting to the community collection system attractive to members of a neighborhood or community where local siting conditions are challenging or not appropriate for individual systems. Connection fees are approximately $15,000 per connection. There are additional costs with demolishing the existing OWTS and updating the site pluming to accommodate the sewer connection, which can cost approximately $10,000 per unit. (Jeff Palmer, personal communication, June 16, 2012.)

The SWRCB has set aside funds from its State Revolving Fund Program that can be made available to local qualified agencies who can then provide low-interest loans to homeowners to repair, replace, or upgrade their OWTS or connect to the sewer system.

7.3.6 Watershed Wide Implementation

7.3.6.1 Riparian Buffers and Stream Bank Stabilization

Riparian buffers consist of an area of trees, usually accompanied by grasses, shrubs, and other vegetation that are adjacent to a waterbody. They reduce the impact of nonpoint source pollution by trapping and filtering sediments, nutrients, and other chemicals from surface runoff and shallow groundwater. The leaf canopy provides shade that keeps the water cool, discouraging algae growth and thus retaining more dissolved oxygen. Trees and shrubs near the waterway stabilize the bank, improve and protect the aquatic environment, and protect stream banks from flood erosion and debris damage. Riparian enhancements may include a wide variety of practices intended to restore the natural condition and function of the river and its riparian area. These practices may include stream bank stabilization and outfall protection, planting of stream bank vegetation and establishment of sufficient stream buffers, removal of invasive plant species, improvement of floodplain connections, removal of fish barriers, and enhancement of wetlands (OCES, 1998).

7.3.7 Matilija Dam Removal

In order to restore ecological function of the Ventura River, removal of Matilija Dam and accumulated sediments behind the dam is planned. A final EIS/EIR was completed in 2004, which identified the preferred dam removal alternative. In the preferred alternative, the entire concrete dam structure above the original streambed will be removed; sediments will be slurried in pipelines to downstream sediment placement sites. This alternative is estimated to take three years to complete.

Slurry disposal site will be within the River's floodplain and the sediments may erode in storm events and contribute to winter nutrient loading. Potential slurry disposal sites are below the Robles Diversion. The sediments from the slurry disposal sites will be protected from erosion up to a 10-year storm.

Prior to the issuance of a Clean Water Act Section 401 Water Quality Certification from the Regional Board for the dam removal project, the project proponents will be required to develop an estimate of the potential for nutrient contributions from the stored sediments during storms and the appropriate level of sediment protection that will be required such that sediments do not cause or contribute to nutrient impairments addressed by this TMDL.

7.4 Monitoring Program

The monitoring programs will be designed to measure improvement in water quality and pollutant load reductions. The monitoring program has several goals including:

- Determine attainment of numeric targets;
- Determine compliance with the waste load and load allocations;
- Monitor the effect of implementation actions on river and estuary water quality.

The TMDL monitoring program will consists of three components 1) receiving water monitoring, 2) discharger monitoring, and 3) optional special studies. All monitoring plans may be included in subsequent permits or other orders and are subject to Executive Officer approval.

7.4.1 Receiving Water Monitoring

Responsible parties (OVSD, Ventura County Watershed Protection District, Ventura County, the City of Ojai, the City of Ventura, Caltrans, and agricultural dischargers) are responsible for developing and implementing a comprehensive monitoring plan to assess numeric target attainment and measure in-stream nutrient concentrations. Responsible parties are encouraged to work together to submit a join watershed-wide plan. Once horse and livestock owners are enrolled in the regulatory mechanism to implement their LAs, they shall participate in the implementation of the watershed-wide monitoring plan or submit their own plan. The monitoring plan should outline a program to sample for algal biomass, algal percent cover, nutrients (total and dissolved), *in situ* water quality parameters (dissolved oxygen, pH, temperature, electrical conductivity), and flow for the river and estuary. The monitoring procedures/methods, analysis, and quality assurance must be SWAMP comparable. The sampling frequency and locations must be adequate to assess beneficial use condition and attainment of applicable water quality objectives. At a minimum algal biomass and pre-dawn DO sampling shall be conducted two times per growing season (May 1st to September 30th); once early in the season and once late in the season. All other parameters, including algal percent cover, shall be monitored monthly.

Existing receiving water monitoring conducted under other programs can be leveraged to assist in meeting these monitoring requirements. Responsible parties may build upon existing monitoring programs in the Ventura River watershed when developing the receiving water quality monitoring plan for this TMDL. Receiving water monitoring requirements shall be incorporated into the regulatory mechanisms for each responsible party upon issuance, renewal, or modification. The responsible parties may continue to coordinate a watershed-wide monitoring program to meet this requirement in order to fulfill permit, WDR, or waiver requirements. Receiving water monitoring shall continue beyond the final implementation date of the TMDL unless the Executive Officer approves a reduction or elimination of such monitoring.

7.4.2 Discharge Monitoring

Discharge monitoring will assess attainment of the waste load and load allocations. Dischargee monitoring shall be required through the regulatory mechanisms used to implement the waste load and load allocations. Discharge monitoring shall be conducted at the frequency specified in Section 7.1 of the TMDL. The monitoring procedures/methods, analysis, and quality assurance must be SWAMP comparable.

7.4.3 Special Studies

Responsible parties within the watershed may conduct optional special studies designed to refine waste load and load allocations and numeric targets. The results of special studies and monitoring may be used to revise numeric targets and allocations, if supported, when the TMDL is reconsidered. The following are potential special studies.

- Build upon the algal biomass and total nitrogen relationship established in the 2008 UCSB Study (UCSB, 2009) and collect data to support the establishment of reach-specific relationships.
- Confirm the conclusion that an algal biomass target of 150 mg/m^2 is fully protective of aquatic life and minimizes the risk of low DO events.
- Collect additional source assessment information and model input data to refine model predicted relationships between watershed loading and in-stream nutrient concentrations.
- Investigate the influence of OWTS on surface water quality.
- Collect data to support development of an estuary model, which takes into account tidal influence, the dynamics of macroalgae and phytoplankton growth, residence time, and breaching conditions.

7.5 Implementation Schedule

The proposed implementation schedule shall consist of a phased approach consisting of monitoring and special studies before allocations become effective as presented in Table 7-9. The schedule allows six to 10 years from the effective date to meet the dry-weather and wet-weather load and waste load allocations in Ventura River and its tributaries.

Table 7-9 Implementation Schedule

Task	Due Date
Submit results of optional special studies.	3 years after effective date of TMDL
Reconsider TMDL to revise numeric targets allocations if supported by special studies	5 years after effective date of TMDL
OVSD	
Wet-weather and interim dry-weather WLAs apply	Effective date of TMDL
Submit receiving water monitoring plan to assess numeric target attainment and measure in-stream nutrient concentrations	1 year after effective date of TMDL
Initiate receiving water monitoring plan	90 days after approval of receiving water monitoring plan
Compliance monitoring plan incorporated into permit	Upon permit adoption, renewal, or modification
Dry-weather WLA apply	10 years after effective date of TMDL
Ventura County MS4 Permitees and Caltrans	
Wet-weather WLAs apply	Effective date of TMDL
Discharge monitoring plan incorporated into permit	Upon permit adoption, renewal, or modification
Submit receiving water monitoring plan to assess numeric target attainment and measure in-stream nutrient concentrations.	1 year after effective date of TMDL
Initiate receiving water monitoring plan	90 days after approval of receiving water monitoring plan
Submit implementation plan to achieve compliance with the WLAs. The plan shall include implementation methods, an implementation schedule, proposed interim milestones, and compliance points.	2 years after effective date of TMDL
Dry-weather WLAs apply	6 years after effective date of TMDL
General Industrial and Construction Stormwater Permittees	
Wet-weather and dry-weather WLAs apply	Effective date of TMDL
Discharge monitoring plan incorporated into permit	Upon permit adoption, renewal, or modification
Other NPDES Permitees	
Wet-weather and dry-weather WLAs apply.	Effective date of TMDL
Discharge monitoring plan incorporated into permit.	Upon permit adoption, renewal, or modification
Agricultural Discharges	
Discharge monitoring plan incorporated into Agriculture Waiver or other order	Upon adoption, renewal, or modification
Submit receiving water monitoring plan to assess numeric target attainment and measure in-stream nutrient concentrations	1 year after effective date of TMDL
Initiate receiving water monitoring plan	90 days after approval of receiving water monitoring plan

Task	Due Date
Wet-weather and dry-weather WLAs apply	6 years after effective date of TMDL
Onsite Waste Water Treatment Systems	
Wet-weather and dry-weather WLAs apply	10 years after effective date of TMDL
Horse/Livestock Owners	
Discharge monitoring plan submitted as part of waiver requirement or in response to Regional Board order	5 years after effective date of TMDL
Join watershed-wide group to conduct receiving water monitoring to assess numeric target attainment and measure in-stream nutrient concentrations or submit own plan	5 years after effective date of TMDL
Wet-weather and dry-weather WLAs apply	10 years after effective date of the TMDL

8. REFERENCES

Ackerman, D. and K. Schiff. 2003. Modeling Storm Water Mass Emissions to the Southern California Bight. Journal of Environmental Engineering, 129 (4): 308-317.

Airaksinen, S., M.-L. Heiskanen, H. Heinonen-Tanski. 2007. Contamination of surface run-off water and soil in two horse paddocks. Bioresource Technology, 98:1762-1766.

American Society of Chemical Engineers (ASCE). 2003. Manure Production and Characteristics. ASAE D384.1

Anderson, C.W. and K.D. Carpenter. 1998. Water Quality and algal Conditions in the North Umpqua River Basin, Oregon, 1992-1995, and Implications for Resource Management. U.S. Department of the Interior, U.S. Geological Survey. Water Investigations Report 98-4125. Portland, OR. 78pp.

Biggs, B. J. 2000. Eutrophication of streams and rivers: Dissolved Nutrient-Chlorophyll Relationships for Benthic Algae. J. N. Am. Benthol. Soc. 19:17-31.

Fetscher, A.E., L. Busse, and P. R. Ode. 2009. Updated May 2010. Standard Operating Procedures for Collecting Stream Algae Samples and Associated Physical Habitat and Chemical Data for Ambient Bioassessments in California. California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP)
Bioassessment SOP 002.

Francesca Bona. Effect of seaweed proliferation on benthic habitat quality assessed by Sediment Profile Imaging. Journal of Marine Systems 62 (2006) 142–151

Bricker, S.B., C.G. Clement, D.E. Pirhalla, S.P. Orlando, and D.R.G. Farrow. 1999. National Estuarine Eutrophication Assessment: Effects of Nutrient Enrichment in the Nation's Estuaries. NOAA, National Ocean Service, Special Projects Office and the National Centers for Coastal Ocean Science. Silver Spring, MD: 71 pp.

S.B. Bricker , J.G. Ferreira, T. Simas. An Integrated Methodology for Assessment of Estuarine Trophic Status. Ecological Modelling 169 (2003) 39–60

Busse, L.B., J. C. Simpson, S.D. Cooper. 2006. Relationship Among Nutrients, Algae, And Land Use in Urbanized Southern California Streams. Can. J. Aquat. Sci. 63: 2621-2638.

California Department of Water Resources. 2004a. Ventura River Valley Groundwater Basin Upper Ventura River Basin. Bulletin 118. February 27, 2004

California Department of Water Resources. 2004b. Ventura River Valley Groundwater Basin Lower Ventura River Basin. Bulletin 118. February 27, 2004

California Stormwater Quality Association (CASQA). 2003. California stormwater BMP handbook: New development and redevelopment. January 2003. http://www.cabmphandbooks.com

California Regional Water Quality Control Board (CRWQCB), Central Coast Region. 2009. Total Maximum Daily Loads for Pathogens in Aptos Creek, Valencia Creek, and Trout Gulch, Santa Cruz County, California. Final Project Report.

http://www.waterboards.ca.gov/rwqcb3/water_issues/programs/tmdl/docs/aptos/pathogens/apt_path_tmdl_att2_projrep.pdf

Center for Watershed Protection (CWP). 1996. *Design of Stormwater Filtering Systems*. Prepared for the Chesapeake Research Consortium, Solomons, MD, and USEPA Region V, Chicago, IL, by the Center for Watershed Protection, Ellicott City, MD.

Daniel B. Stephens & Associates, Inc. August 20, 2010. Draft Groundwater Budget and Approach to a Groundwater Management Plan, Upper and Lower Ventura River Basin.

Devinny et al., 2004. Devinny, Joseph S., S. Kamieniecki, and M. Stenstrom "Alternative Approaches to Storm Water Quality Control" (2004), included as App. H to Currier et al. "NPDES Stormwater Cost Survey" (2005).

Dodds, W. and Welch, E. 2000. Establishing Nutrient Criteria in Streams. J. N. Am. Benthol. Soc. 19(1): 186-196

Farm Bureau of Ventura County. 2010. Written Communication with Los Angeles Regional Water Quality Control Board, "Re: Dry Weather Irrigation Runoff Estimates for the development of the algae TMDL for the Ventura River." Jan. 29, 2010.

Green, Lauri. Macroalgal Mats Control Trophic Structure and Shorebird Foraging Behavior in a Southern California Estuary. Dissertation, UCLA 2011.

Harper, H. H., Herr, J. L., Livingston, E.H. 1999. Alum Treatment of Stormwater: the First Ten Years. New Applications in Modeling Urban Water Systems. CHI, Guelph, Ontario, Canada.

Hawks & Associates. 2009. Preliminary Horse Survey Oct. 2009.

Kayhanian, M., L. Hollingsworth, M. Spongberg, L. Regenmorter, K. Tsay. 2002. Characteristics of Stormwater Runoff from Caltrans Facilities

Kristie Klose, Scott D. Cooper, and Al Leydecker. An Assessment of Numeric Algal and Nutrient Targets for Ventura River Watershed Nutrient Total Maximum Daily Loads (TMDLs). Final Report, May 2009. Marine Science Institute, Department of Ecology, Evolution, and Marine Biology University of California, Santa Barbara

Larry Walker Associates, 2011. Corrected Source Assesment Report: Nitrogen and Phosphorus in the Ventura River Watershed.

LARWQCB, 1996. 1996 California Water Quality Assessment - 305(b) Report supporting documentation for Los Angeles Region.

LARWQCB, 1998. 1998 List of Impaired Surface Waters (The 303(d) list). Los Angeles Regional Water Quality Control Board.

Lu, Rong, Schiff, Kenneth C., Stolzenbach, Keith D. Nitrogen Deposition on Coastal Watersheds in the Los Angeles Region. 2003-2004. Southern California Coastal Water Research Project Annual Report. pp. 73-81.

Reports by Al Lydecker of University of California-Santa Barbara, Marine Science Institute, Department of Ecology, Evolution, and Marine Biology

Lydecker, Al. Boom or Bust? October 31, 2003.
Lydecker, Simpson, Grabowski, and Lim, 2004. Nutrient Uptake and Cycles of Change: The Ventura River in Southern California
Lydecker, Al. Watershed U Handout, March 26, 2010.
Lydecker, Al. A July Look at Algae on the Ventura River, July 17, 2008.
Lydecker, Al. We're Back, September 28, 2008.
Lydecker, Al. A Look at Nutrient Concentrations in the Ventura Watershed: 2008-2011 March 15, 2012.

Marty Melvin. 2012. Personal Communication with Los Angeles Regional Water Quality Control Board, "Re: Cattle Numbers." June 8, 2012.

McLaughlin K., M. Sutula, L. Busse, S. Anderson, J. Crooks, D. Gibson, K. Johnston, L. Stratton, L. Tiefenthaler 2012. Southern California Bight 2008 Regional Monitoring Program: Estuarine Eutrophication Assessment. Southern California Coastal Water Research Project. Costa Mesa, CA.

MWH. 2007. Conceptual evaluation of process retrofit alternatives to achieve low nutrient discharges. Technical memorandum. Ref # 1342830/6.2

National Marine Fisheries Service, Southern California Steelhead Recovery Plan Summary. Southwest Regional Office, Long Beach, CA. January 2012

NRCS, 2000. USDA-NRCS Field Office Technical Guide. Downloaded from: http://efotg.nrcs.usda.gov/treemenuFS.aspx. Retrieved May 23, 2012.

NRCS FOTG Cost Data. 2010. ftp://ftp-fc.sc.egov.usda.gov/Economics/Costs/eFOTG/California/FY2010/

OCES, 1998. Oklahoma Cooperative Extension Service, Oklahoma State University. Riparian Area Management Handbook. E-952.

SCAG. 2005. Southern California Association of Governments. 2005 Land Use Data Update.

C.M. Scanlan, J. Foden, E. Wells, M.A. Best. The Monitoring Of Opportunistic Macroalgal Blooms for the Water Framework Directive. Marine Pollution Bulletin 55 (2007) 162–171

SCCWRP, 2007. Assessment of water quality concentrations and loads from natural landscapes. ED Stein, VK Yoon. Technical Report 500. Southern California Coastal Water Research Project. Costa Mesa, CA.

Schueler, T. 1987. Controlling urban runoff: a practical manual for planning and designing urban BMPs. Metropolitan Washington Council of Governments.

Stein, Eric and V. Yoon. 2007. Assessment of Water Quality Concentrations and Loads from Natural Landscapes. Southern California Coastal Water Research Project. Technical Report 500. February 2007.

Sutula M. (2011). Review of Indicators for Development of Nutrient Numeric Endpoints in California Estuaries. Southern California Coastal Water Research Project Technical Report No. 646. December 2011.

SWRCB, 2004. Policy for implementation and enforcement of the nonpoint source pollution control program (NPS Implementation and Enforcement Policy). May 2004.

SWRCB, 2012. Onsite Wastewater Treatment System Policy - Draft Substitute Environmental Document. June 6, 2012.

Tetratech. 2006. Technical Approach to Develop Nutrient Numeric Endpoints for California, 2006 Prepared by Tetra Tech Inc. For U.S. EPA Region IX

Tetratech. 2008. Data Summary Report – Ventura River Watershed Hydrology Model.

Tetratech. 2012. Ventura River Estuary and Flow Conditions. June 30, 2012.
Municipal Technology Branch (2004), U.S. Environmental Protection Agency, Washington, DC 20460. EPA832-R-93-005. http://water.epa.gov/type/wetlands/constructed/index.cfm

U.S. EPA, 2000a. Guidance for developing TMDLs in California. EPA Region 9. January 7, 2000.

US EPA, Office of Water. Nutrient Criteria Technical Guidance Manual. EPA-822-B-00-002. July 2000b

US EPA. 2000c. Constructed Wetlands Treatment of Municipal Wastewaters. National Risk Management Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio 45268. EPA/625/R-99/010. http://www.epa.gov/ORD/NRMRL

US EPA. 2003a. Constructed Wetlands for Wastewater Treatment and Wildlife Habitat: 17 Case Studies

US EPA. 2003b. National Management Measures to Control Nonpoint Pollution from Agriculture. EPA 841-B-03-004, July 2003

U. S. EPA National Menu of Stormwater Best Management Practices http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm. Accessed on September 19 and 20, 2007.

USDA. 2009. United States Department of Agriculture. 2007 Census of Agriculture.

US EPA Causal Analysis/Diagnosis Decision Information System (CADDIS). Volume 2: Sources, Stressors & Responses. http://www.epa.gov/caddis/ssr_home.html. Accessed on July 16, 2012.

USDA. Manage Nutrient Database. http://www.ars.usda.gov/Research/docs.htm?docid=11079

Vada. K. Yoon and E. Stein. 2008. Natural Catchments as Sources of Background Levels of Storm-Water Metals, Nutrients, and Solids. Journal of Environmental Engineering, 135 (12): 961-973. December 2008.

Ventura County Agricultural Irrigated Lands Group (VCAILG).2008. 2007 Annual Monitoring Report. February 15, 2011.

Ventura County Agricultural Irrigated Lands Group (VCAILG).2009. 2008 Annual Monitoring Report. February 15, 2011.

Ventura County Agricultural Irrigated Lands Group (VCAILG).2010. 2009 Annual Monitoring Report. February 15, 2011.

Ventura County Agricultural Irrigated Lands Group (VCAILG).2011. 2010 Annual Monitoring Report. February 15, 2011.

Ventura Countywide Stormwater Quality Management Program (VCSQMP). 2001. Stormwater Quality Management Plan.

Ventura Countywide Stormwater Quality Management Program (VCSQMP). 2010. 2009/2010 Water Quality Monitoring Report.

Ventura County Watershed Protection District. February 10, 2010. Memorandum: "Ventura River Basin Groundwater Nitrate information."

Ventura River Steelhead Restoration Plan, December 1997. Prepared by Entrix Inc. (Walnut Creek, CA) and Woodward Clyde Consultants (Santa Barbara, CA) Project No. 351001

Welch, E.B. and J. M. Jacoby. 2004. Pollutant Effects in Freshwater: applied Limnology, Third edition. Spon Press. London, UK. 504 pp.

Wetzel. 2001. Limnology: Lake and River Ecosystems. Third Edition. Academic Press. London, UK. 985 pp.

W2. 2010. Waste to Energy (W2) Anaerobic Digester for the Ojai Valley Project Introduction. September 9, 2010.